COMBUSTION

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DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

May, 1946

UNIVERSITY OF MINNESOTA

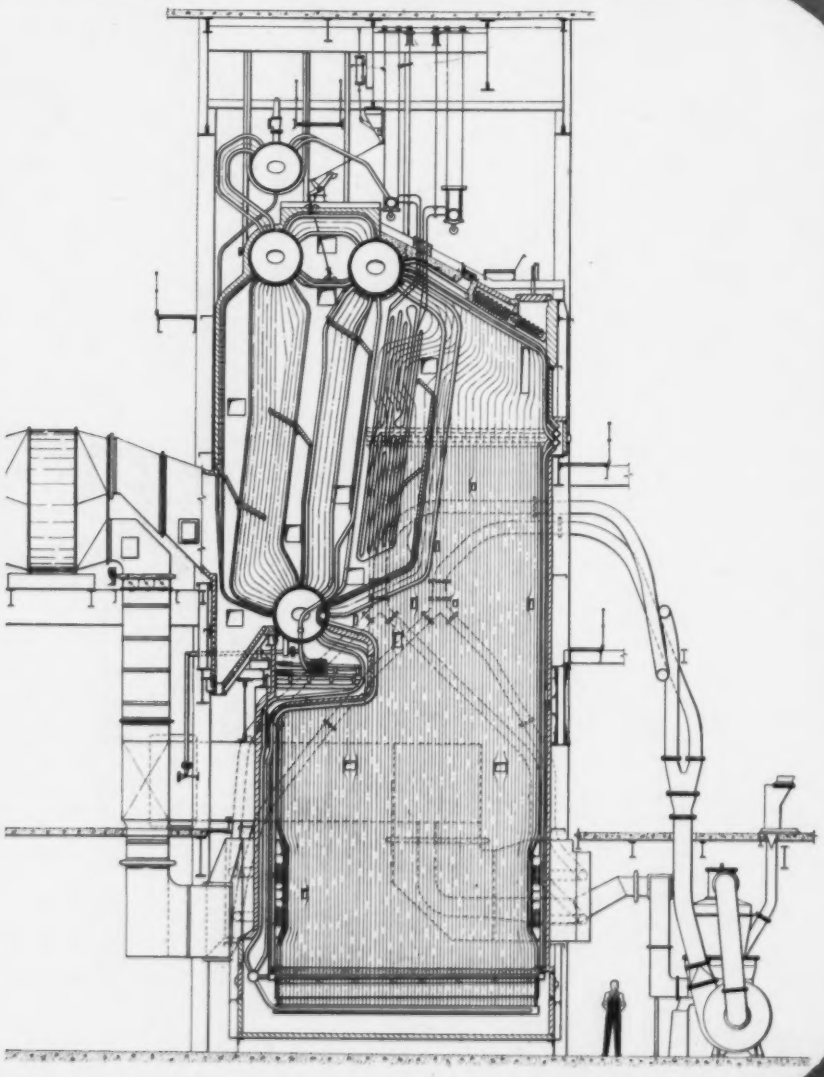
Power Plant at University of North Carolina (see page 45)

Electric Steam-Generation Installation

Reduction in Turbine Blade Deposits

Fabrication of Boiler Drums—Part 3

REEVES AVE. STATION *Repeats*



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COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

VOLUME 17 NUMBER 11

Contents

MAY 1946

Feature Articles

Electric Steam Generator Installation at Salem Alumina Plant.... .....*By George H. Krueger* 24

Gas Turbine Under Test by Navy. 31

Combustion Control at University Power Plant..... 35

Fabrication of Boiler Drums, Part III—Testing and Finishing..... .....*By H. R. Towse* 36

Reduction of Turbine-Blade Deposits by Water Conditioning.... ..*By M. E. Fitze and F. H. Long* 41

Editorials

It Must Not Happen Again..... 23

The Merchant Marine..... 23

Departments

Review of New Books..... 49

Catalogs and Bulletins..... 50

Advertisers in This Issue..... 52

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Editorials

It Must Not Happen Again

The often-repeated assertion that bituminous coal, regardless of competitive fuels and hydro power, is basic to survival of American industry and our accustomed ways of living, has gained added emphasis by the effects of the coal strike. In the past there have been many stoppages of coal supply but never have they been so far-reaching and devastating. Coming at a time when shelves are bare of much-needed commodities, and so closely upon the heels of the steel strike, there was neither time to catch up with demand nor to build up a backlog of materials to meet reconversion needs. Moreover, never before have transportation, utility services and industrial users of coal been so adversely affected. Ramifications of the stoppage have been so extensive that it is estimated that normal deliveries of equipment and commodities will have been delayed from six to twelve months.

The situation has been further aggravated by concurrent strikes, some of long standing, in copper mining, in the manufacture of electrical equipment and other appliances that constitute component parts of new installations, and in supplies for various manufacturing operations.

The resulting unemployment has more than offset any monetary gains by the labor groups directly concerned and has penalized thousands of workers in other fields, besides inflicting untold losses to industry and business in general.

Regardless of the terms of settlement in the coal controversy, public welfare makes it imperative that steps be taken to prevent a recurrence of the situation.

The Merchant Marine

On May 22 this country observed National Maritime Day, dedicated by Presidential Proclamation to the American Merchant Marine. The date represented the one hundred twenty-seventh anniversary of the sailing of the steamship *Savannah* on the first successful crossing of the Atlantic by steam.

One of the marvels of the war effort was the speed and the extent to which our shipbuilding program was consummated. Our possession of the world's largest merchant fleet is a most valuable national asset—a position that must not be permitted to retrograde, as has happened several times since the *Savannah* first crossed the Atlantic.

Having acquired the construction facilities, the experience and the means for training personnel, this country cannot afford to rest upon its wartime accomplishments. It must carry forward, by new construction and by improved practice in steam engineering, to meet most effectively the needs of peacetime commerce, and thus maintain its position as a leading maritime power. This, in effect, was the purpose of National Maritime Day.

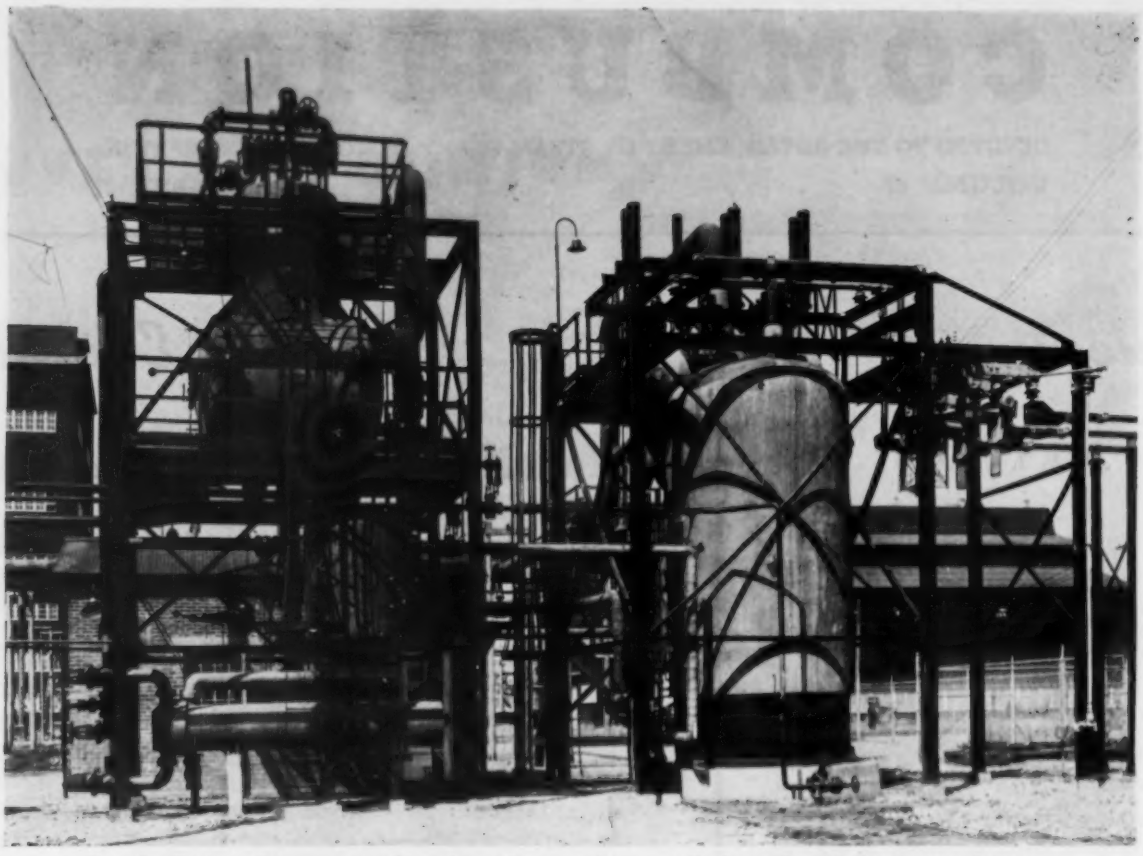


Fig. 1—Boiler, disconnects, blowdown heat exchanger, flash tank and deaerating heater

Electric Steam Generator Installation at Salem Alumina Plant

By GEORGE H. KRUEGER

Mech. and Steam Engr., Bonneville Power Administration

Description of a 150,000-lb per hr 150-psi, 50,000-kw Kaelin type single-drum electric boiler installed near Salem, Ore., to furnish steam for the production of alumina from local clays. This is the largest electric steam generator built in the United States to date. Electric energy is supplied by the Bonneville Power Administration and reduced in voltage through a substation and transformers to 6.9 kv at the boiler. Excepting the feed pumps and automatic controls, all equipment is installed outdoors.

THE "Alumina from Clay Plant" was built by the Chemical Construction Corporation of New York for the Defense Plant Corporation. It is located just north of the city limits of Salem, Oregon, a short distance from the Willamette River and on the main line of the principal coastal railroad. This plant was designed and built as an experimental unit to determine the economic feasibility of producing alumina from the high alumina clays that exist in abundance in the states of Washington and Oregon. In the process of recovering the alumina from clay, large quantities of process steam are required, but this article is concerned only with the electric steam-generating unit lately installed at the plant.

Three kinds of fuel to provide heat for steam generation at the boiler plant were originally considered: (1) hogged fuel or sawmill wood waste, (2) fuel oil, and (3) coal. Analysis of the use of these three fuels resulted in the following conclusions: (*a*) The supply of hogged fuel was diminishing and it appeared probable that this type of fuel would completely vanish from the market due to its higher value as a material for manufacturing wood by-products. (*b*) Because of war conditions the supply of fuel oil was very critical and unavailable, large quantities being required for naval and merchant vessels and for vital heating uses in the area. (*c*) Coal prices were relatively high and it would be necessary to use vital transportation facilities to ship the coal to the Alumina plant. The nearest local coal available was

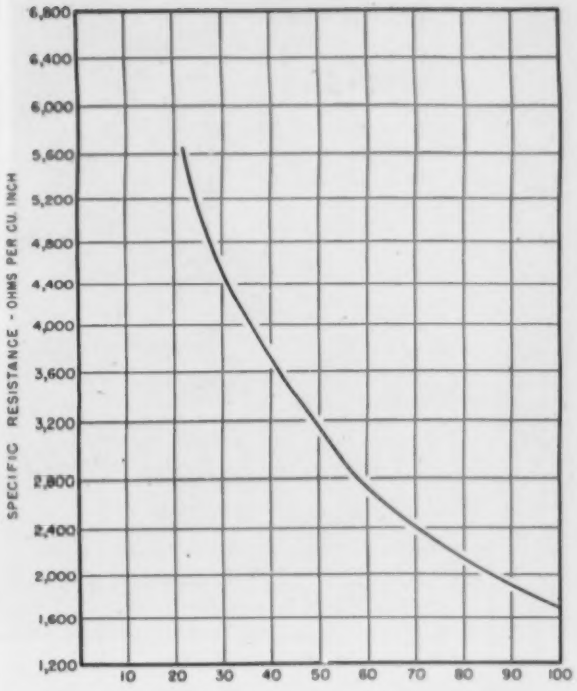


Fig. 2—Specific resistance-temperature curve

lignite from Lewis County, Washington, a distance of approximately 150 mi from Salem. Other coals would have to be shipped from Wyoming or Utah, which meant a 1500-mi rail haul.

After due study of the boiler fuel situation in the Pacific Northwest by Chemical Construction Corporation's engineers, it was suggested that consideration be given to the use of electric steam generators to supply the necessary process steam for the new plant. This method of steam production was given consideration for the reason that low-cost electric energy was available in this area. The final conclusion was reached that electric steam generation had advantages that were not available in solid and liquid fuel-fired steam boilers.

The electric steam generator which was installed is a 50,000-kw Kaelin type, single-drum unit manufactured by the Combustion Engineering Company, Inc. It is the largest single-drum three-phase unit built in the United States to date. General characteristics of the boiler plant are listed in the following tabulation:

STEAM CHARACTERISTICS

Normal steam generating capacity	150,000 lb per/hr
Working steam pressure	150 psi
Boiler design pressure	160 psi
Quality of steam	99.7 per cent dry
Feedwater temperature	225 F
Condensate return	None
Makeup water	100 per cent raw water

ELECTRICAL CHARACTERISTICS

Electric rating of steam generator	50,000 kw
Potential on electrodes	6.9 kv

CONTROLS

Pneumatic-type completely automatic controls were chosen in order to eliminate boiler room attendance as far as possible and to insure steady operation.

Since water serves as the resistance element in this type of boiler, the water characteristics are very important. Boiler feedwater characteristics must be such that the dissolved solids are low enough and of such a nature that the ohmic resistance is maintained above 1000 ohms per cu in. at 212 F or 100 C. Fig. 2 shows a specific resistance and temperature curve of Willamette River water at Salem.

Electric boiler operation is comparatively simple. Fig. 3 is a diagrammatic sketch illustrating the principal components of a typical Kaelin single-drum unit. The three electrodes *C* are of cast iron and are connected to the three terminals *K* by copper connections which pass through the bushings *G*, each electrode being a terminal for each phase of a three-phase circuit. The electrodes are surrounded by a neutral or steel ground plate *B* built in the form of a clover leaf. Water enters the main drum *A* through the feed connection near the bottom of the unit. When the electrodes are wholly or partially immersed in water, and the current turned on, electrical energy flows through the water from electrode to neutral, neutral to electrode, and between electrodes. The water acts as the resistance element to transform the electrical energy into heat energy which raises the temperature of the water above its vaporization point, generating steam at any desired predetermined pressure. Steam thus generated leaves the main drum and passes through the riser tubes *E* into the dry drum *D*, where any moisture carryover is separated by a steam scrubber. The moisture carryover is returned to the main drum through the dry-drum drain tubes *F* and dry

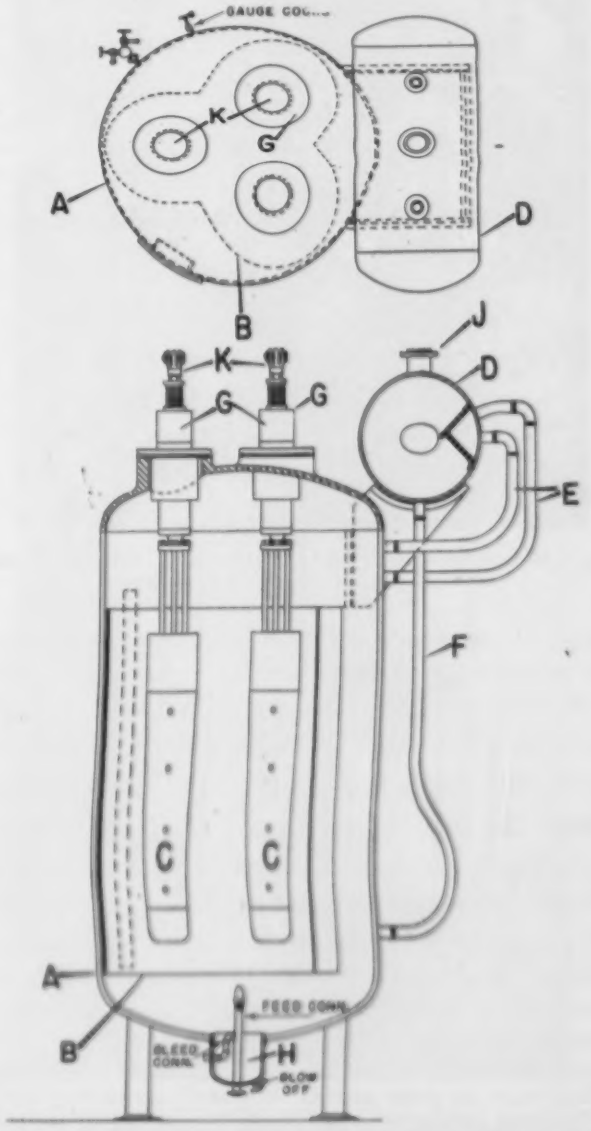


Fig. 3—Diagram of Kaelin single-drum electric boiler

steam is supplied to the steam line through the main steam nozzle *J*. The continuous bleed controlling the concentration of the water is taken off through the bleed connection near the top of the mud drum *H*. A blowoff connection is at the bottom of the mud drum.

The amount of steam generated depends upon the amount of current passing through the water, and this in turn depends upon the area of the path of the electrical energy through the water and the resistance of the water. The water area through which the current can pass is determined by the depth of immersion of the electrodes. Therefore, by maintaining a constant resistance of water, the amount of steam generated may be controlled simply by varying the level of the water in the drum. The water level is indicated by gages mounted on the side of the drum and is controlled by means of the feed and blowdown valves. Control may be either automatic or manual, although automatically operated controls are provided on this installation.

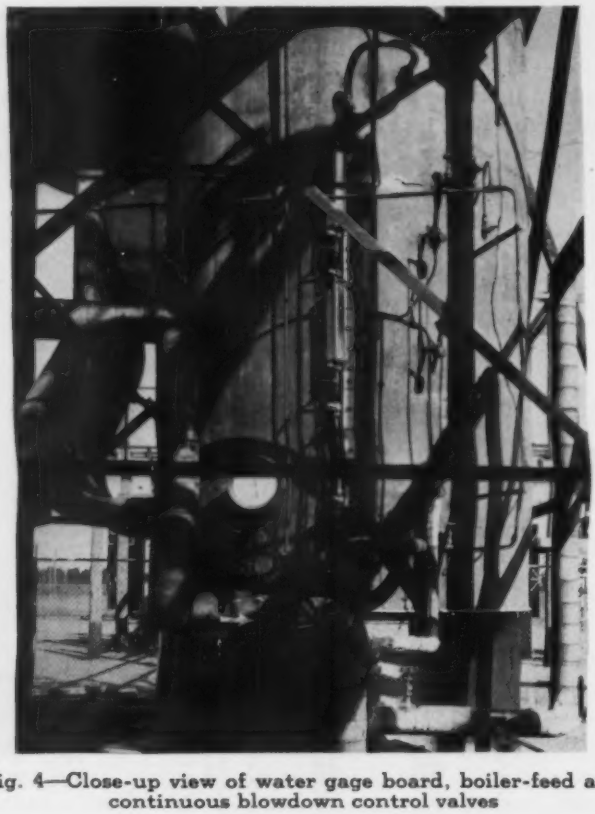


Fig. 4—Close-up view of water gage board, boiler-feed and continuous blowdown control valves

Fig. 1 is an overall picture of the installation in which can be seen the main boiler (the large vertical drum to the right of the center of the picture), electrical disconnects (to right of main boiler), blowdown heat exchanger (the horizontal cylinder near the ground at left), flash tank (above the heat exchanger), and the deaerating feedwater heater (above the flash tank). The heat exchanger and the flash tank are installed for the purpose of recovering as much heat as possible from the boiler blowdown. Most of the heat which would otherwise be lost in the blowdown process is thus recovered and is utilized in heating the incoming feedwater. On the left side of the main boiler drum can be seen the water level gages which have an outer protective glass housing that serves to prevent accidents to personnel in case one of the glass gages breaks because of sudden temperature change.

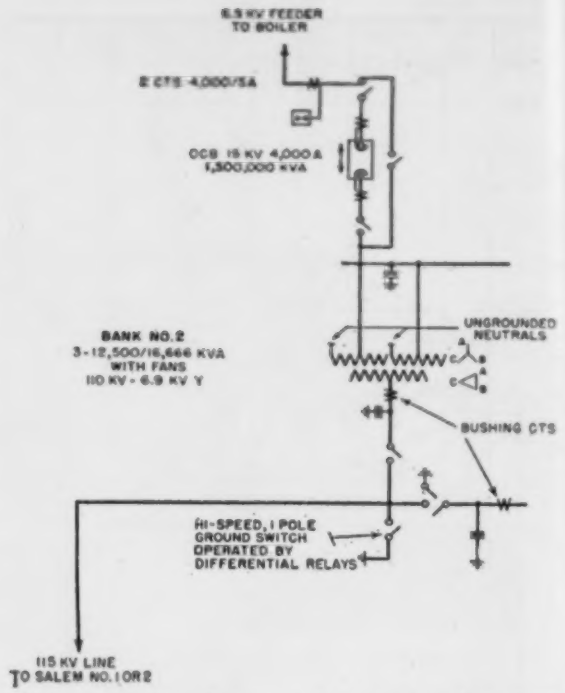

6.9 KV FEEDER TO BOILER
CTS-4,000/5A
OCB 15 KV 4,000A 1,500,000 KVA
BANK NO.2
3-12,500/16,666 KVA WITH FANS
110 KV - 6.9 KV Y
UNGROUNDED NEUTRALS
BUSHING CTS
HI-SPEED, 1 POLE GROUND SWITCH OPERATED BY DIFFERENTIAL RELAYS
115 KV LINE TO SALEM NO. 1 OR 2

Fig. 5—Single-line diagram of energy supply to boiler

Fig. 4 is a close-up photograph of the water-level gage board, the hand-operated boiler feed and continuous blowdown control valves.

The specific resistance of the water is a function of the amount of dissolved solids and also of the temperature of the water. Enough water must be bled off to maintain the concentration of solids at a predetermined point and hence the resistance at the desired point. The bleed water is much more highly concentrated than

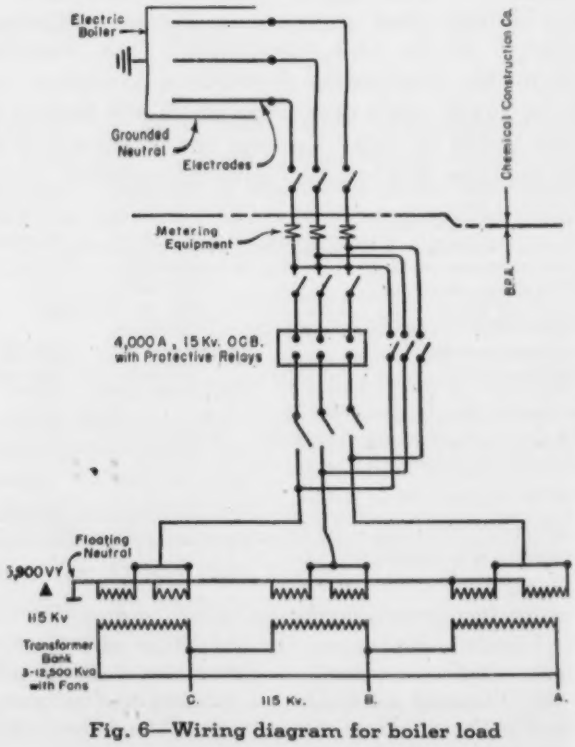


Fig. 6—Wiring diagram for boiler load

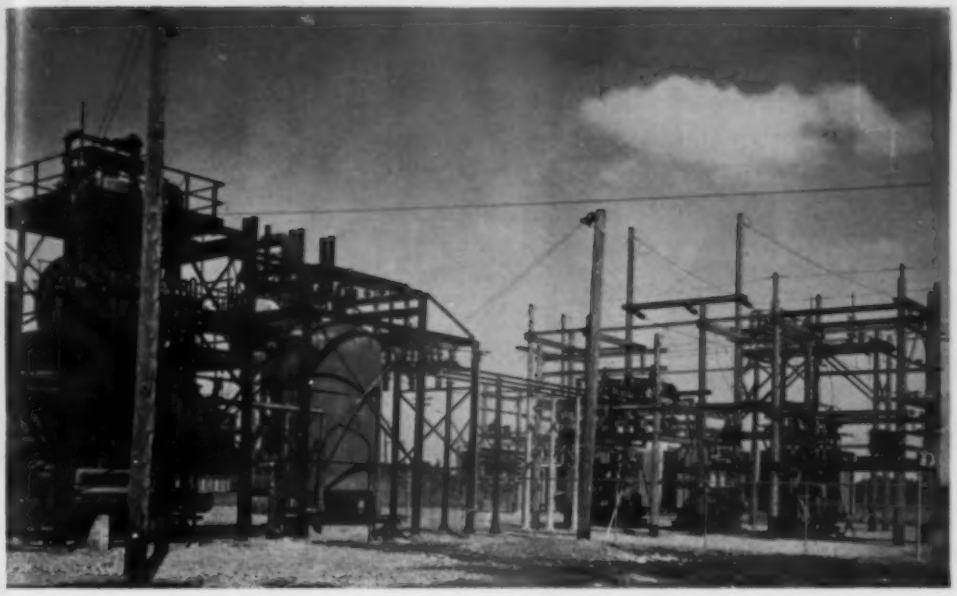


Fig. 7—View of boiler plant and 115/6.9-kv substation

the feedwater, and the proportion of bleed depends entirely upon the quality of the feedwater.

Since the electrical input to the boiler varies directly with the submerged surface area of the electrodes, the height of the water in the drum is in direct proportion to the steam output. The temperature of the unit never exceeds the saturated steam temperature at the maximum pressure of operation, and there is no danger from too low a water level. Steam can be raised to the normal operating pressure in about 15 or 20 min from the time the electric power is turned on, and the full steam flow can be maintained shortly thereafter. When the demand for steam ceases, the unit can be shut down immediately by cutting the power input.

Electrical energy is supplied to the boiler at 6.9 kv from an adjacent Bonneville Power Administration substation. Figs. 5 and 6 are one line and typical wiring diagrams, respectively, showing how energy is received at the substation from the 115-kv lines and finally delivered to the boiler at 6.9 kv. The voltage is reduced to 6.9 kv by three 12,500/16,666-kva transformers fitted with fans. Between these transformers and the metering equipment are three 15-kv, 4000-amp oil circuit-breakers which serve as protection to the transformers in case of a short-circuit at the boiler. A view of the substation and most of the boiler installation can be seen in Fig. 7. A unique feature of the Alumina boiler plant is the outdoor construction of the major portion of the installation. The wooden poles shown carry the flood lighting around the boiler installation.

Fig. 8 is a view of the west end of the installation and shows the concrete blowdown sump (in the foreground), the continuous blowdown heat exchanger, flash tank, deaerating feedwater heater, and the pump house (the brick building).

The north side of the installation is shown in Fig. 9 in which can be seen the dry drum (above the main boiler), the steam pipe line leaving the dry drum, the flow meter connections (on right side of top portion of steam pipe line), the inclosure containing the riser tubes (below the dry drum), and the dry drum drain tubes (all of the tubes entering the main drum below its middle).

Fig. 10 is a photograph of the installation from the northeast and provides an excellent view of the 6.9-kv bus and disconnects.

Fig. 11 shows the boiler feed pumps inside the brick building. The two pumps in the foreground are steam turbine-driven and the one in the right background is electrically driven, the latter being used for starting up purposes and standby services.

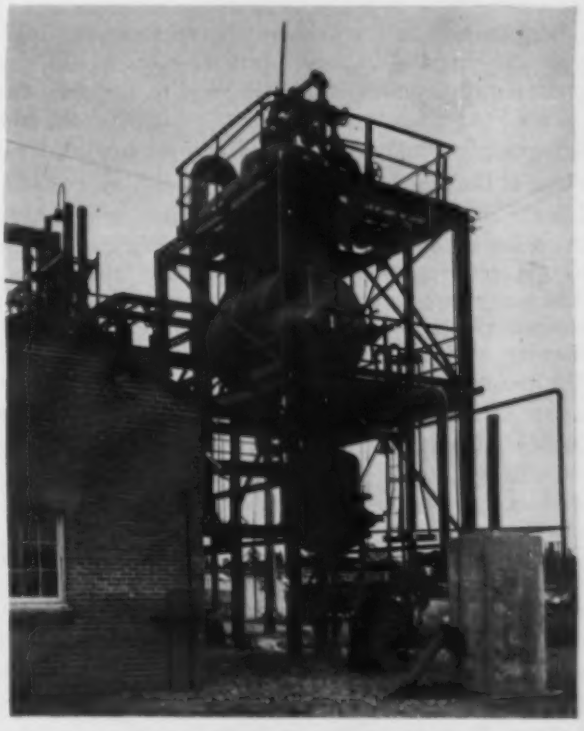


Fig. 8—Showing blowdown sump, continuous blowdown heat exchanger, flash tank, deaerating heater and pump house

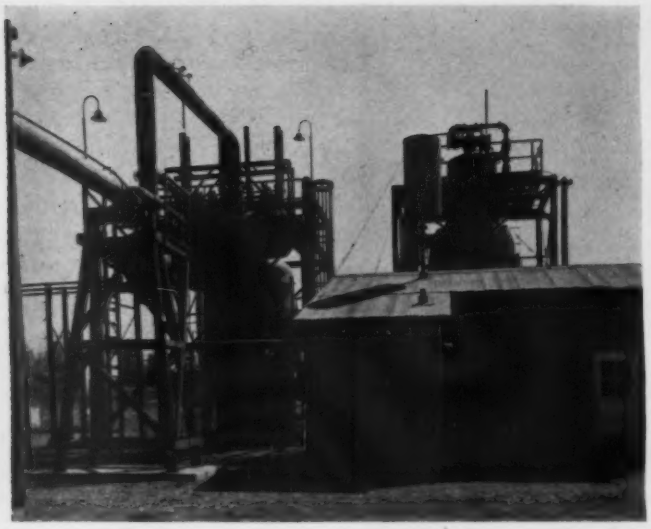


Fig. 9—North side of boiler and pump house showing steam pipe from dry drum and flow meter connections

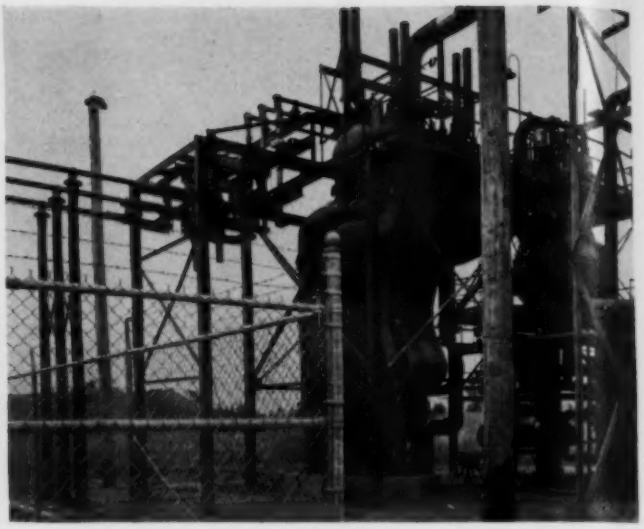


Fig. 10—Northeast side of boiler showing 6.9-kv disconnects and bus

These photographs illustrate the relatively small space and building construction required for an electric boiler installation capable of furnishing 150,000 lb of steam per hour. The brick building shown is approximately 20 ft square and houses the automatic boiler controls, the panel board, and the three boiler feed pumps.

Reproductions of records provided by some of the boiler's automatic recording instruments are furnished in the charts designated as Charts *A* to *E*, inclusive. These charts are all for the same day, that of July 29, 1945, which may be regarded as a typical day.

Chart *A*, Fig. 12, shows the electrical input in thousands of kilowatts with vertical lines to represent each thirty minutes of the day and horizontal lines to represent each thousand kilowatts. This chart shows that there are few sharp changes in the electric energy demand and that the peak demand remains constant for one and one-half hours. At the present time this boiler is operating at only partial capacity but as soon as the plant gets into full production it will require the full steam capacity. At that time the electric load for the boiler will be nearly constant at 50,000 kw for a considerable portion of the day.

Chart *B*, Fig. 13, shows the water conductivity. The numbers on the chart have no specific meaning; they are relative only and simply show the variation in the water conductivity. Records provided by water conductivity charts are valuable in analyzing the boiler feedwater and its reaction to increase and decreases in the steam load on the boiler, and to the blow-down.

Chart *C*, Fig. 13, shows the boiler water level in tens of inches. Charts such as this are used to determine the most efficient water level under various conditions of feedwater flow, water conductivity, boiler blowdown and steam flow.

Chart *D*, Fig. 13, shows the temperature and flow of the boiler feedwater. The lighter line indicates the temperature in degrees Fahrenheit and the darker line the steam flow in thousands of pounds per hour. This chart is valuable in showing the effect of changes in boiler feedwater temperature on the water conductivity and steam flow, as well as to show the amount of feedwater required for the steam load.

Chart *E*, Fig. 13, shows the boiler pressure and rate of steam flow. The lighter line indicates the pressure in pounds per square inch and the darker line the rate of steam flow in thousands of pounds per hour. As can be seen from this chart, pressure in the boiler varies considerably over relatively short periods of time, due to fluctuating loads. With the aid of these graphic charts, the operator is enabled to detect any faulty operation immediately and apply corrective means.

Installation of an electric boiler instead of a fuel-fired boiler in this plant provides many advantages, some of which are: a substantial saving in initial investment; a considerable saving in building space which would have been necessary to house a fuel-fired boiler and provide fuel storage; a saving in manpower and labor costs since the electric boiler requires only one attendant per shift; no railroad trackage required to handle the incoming fuel supply cars and the outgoing ash which offered a serious disposal problem in the area; dependable steam generation at fixed cost even though labor disturbances or other factors cause a shortage, or rise in price of either liquid or solid fuel; and a cleaner plant, requiring less outdoor maintenance, due to no coal dust, ash or smoke.

Fig. 11—Boiler feed pumps inside building

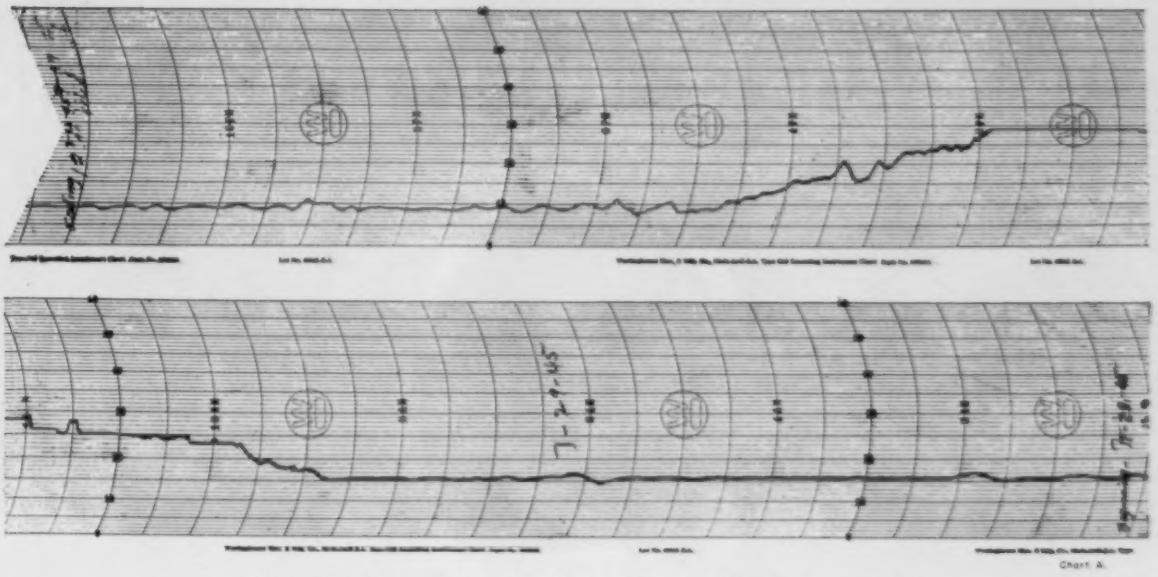


Fig. 12—Chart A showing electric demand for 24-hr period

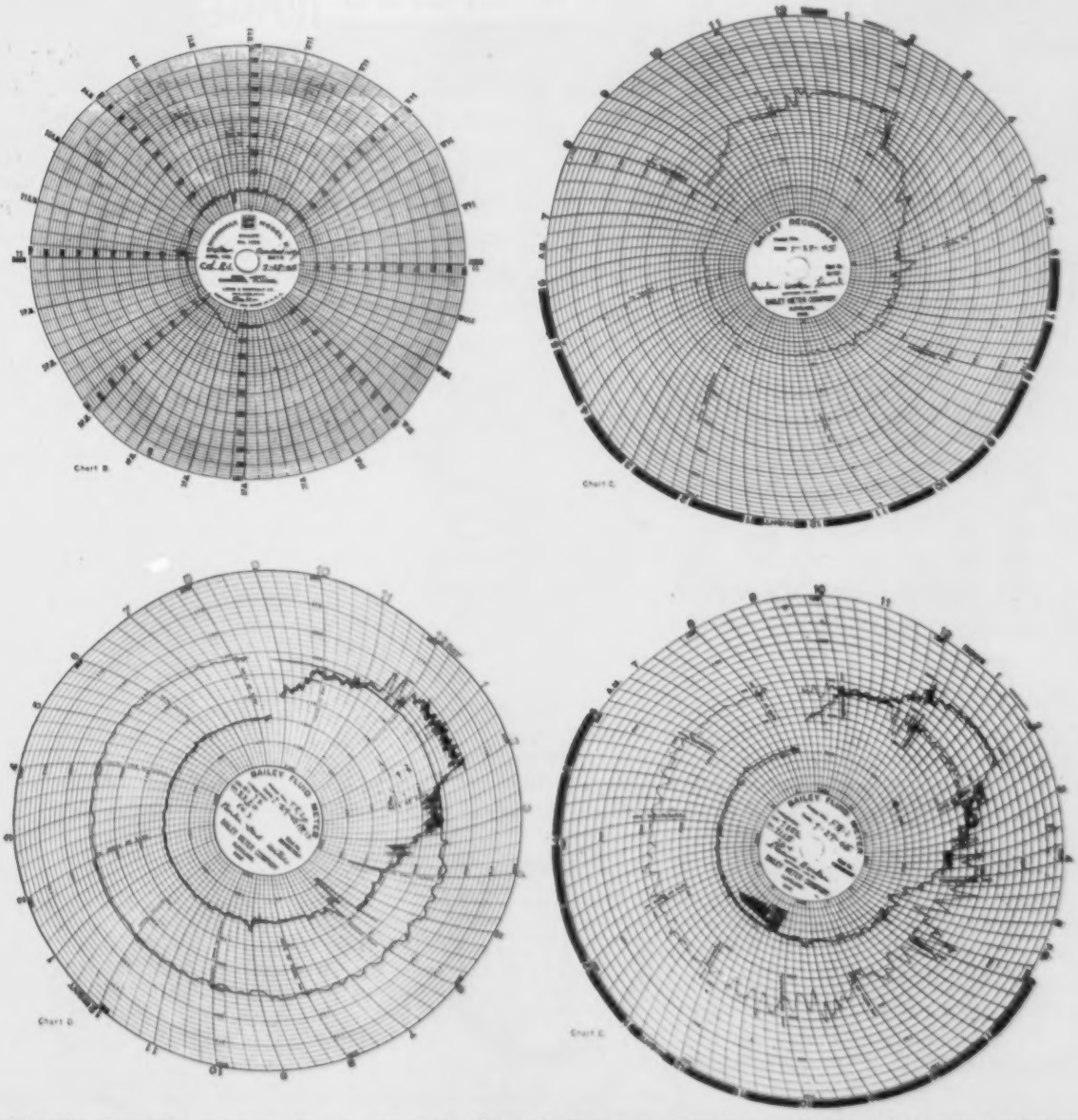
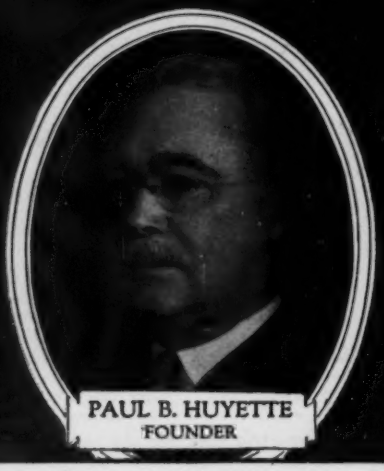


Fig. 13—Chart B, water conductivity record; Chart C, boiler water level record; Chart D, boiler feedwater record; Chart E, boiler pressure and steam flow record

THE PAUL B. HUYETTE CO., Inc.



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The PAUL B. HUYETTE CO., Inc. celebrates its 50th Anniversary this year, and takes this opportunity to express its appreciation of the patronage it has enjoyed from the Power Plant industry during the half-century just completed. Great changes have taken place in that industry since young Paul B. Huyette founded this business in 1896 . . . and who knows what tremendous changes will take place in the *next* 50 years? But it is our purpose to see that there will be no change in the quality of Huyette products and Huyette service.

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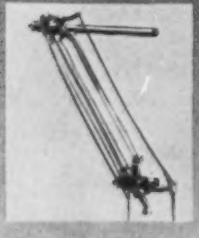

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GAS TURBINE Under Test by the Navy

Features of a 3500-hp gas turbine that has been under exhaustive test during the past two years at the Naval Experiment Station, Annapolis. Thus far satisfactory operation has been attained with gas inlet temperatures up to 1350 F and further tests will be made at 1500 F.

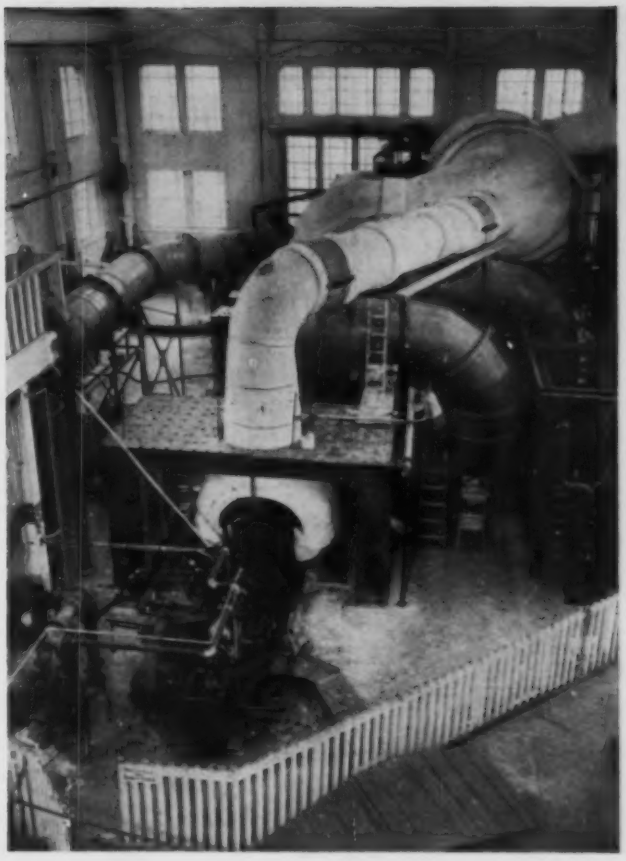


Fig. 1—Gas turbine on test floor viewed from power turbine end; the regenerator is at upper right

SINCE 1941 the Navy has been engaged in development of the gas turbine in cooperation with several commercial firms. Among these was the Allis-Chalmers Company with which the Navy contracted for an experimental turbine of 3500 hp which has been under test at the Naval Engineering Experiment Station at Annapolis for the past two years. Security reasons prevented publicity on this unit until recently when a press demonstration was given on March 29.

The performance of gas-turbine-driven superchargers for military planes and for jet propulsion during the war is now well known, these units having operated at acceptable periods at an inlet temperature of 1600 F. They were designed to meet military requirements in which relatively short service life was acceptable. However, for commercial applications it is necessary that multiple-stage turbines be developed for reliable operation over long periods at inlet temperatures around 1500 F. The unit at Annapolis was designed to provide information for designers with this operating temperature, and during the last two years it has operated at progressively increasing inlet temperatures and recently completed a series of test runs at 1350 F.

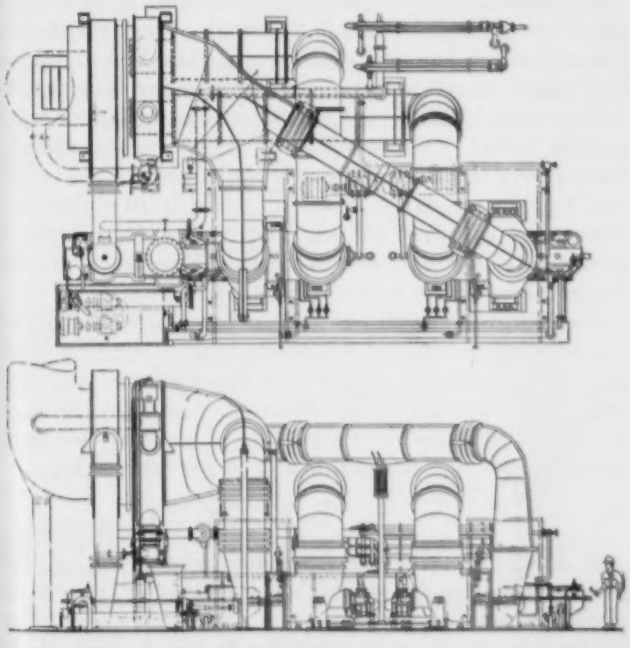


Fig. 2—Elevation and plan of complete gas turbine unit

The cycle selected for this experimental unit involves the use of a parallel turbine arrangement, one turbine driving the compressor and the other the propeller through electric transmission. For test purposes the power of the second turbine is absorbed by a water brake, or dynamometer. Referring to the cycle diagram, Fig. 3, air enters the gas generator compressor at atmospheric pressure and is compressed to 45 psig. It then passes to the heat-exchanger or regenerator, where at full load it is heated by the turbine exhaust 363 F at the compressor discharge to 750 F at the entrance to the two combustion chambers. One of these supplies the compressor turbine and the other the power turbine. With this arrangement it is possible to control the two turbines independently. The exhaust gases, after giving up heat to the compressed air in the regenerator, leave at 637 F to the stack.

It has been pointed out that other cycles might have been used to obtain higher thermal efficiency, but thermal efficiency in this case was considered of secondary importance to flexibility.

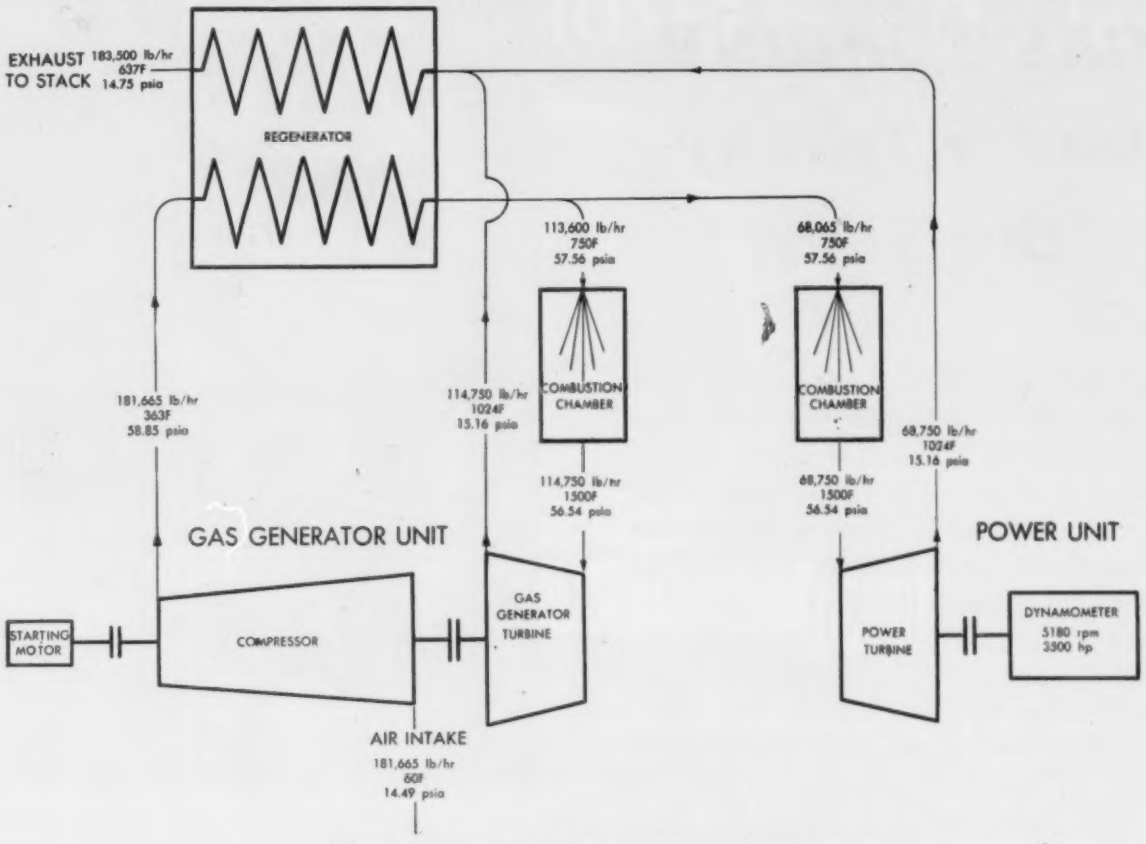


Fig. 3—Cycle diagram for experimental unit

Obviously, on shipboard a more compact arrangement of components would be employed than that shown by the photographs taken on the test floor at Annapolis where convenience for inspection and the taking of readings was paramount.

The compressor is of the axial-flow type with 20 stages of airfoil section blades, so arranged that the air is accelerated by the moving blades and then slowed down in the stationary elements in such a manner that part of the velocity energy is converted into pressure. When compressing the full-load volume of 40,000 cfm against the operating head of 45 psig, the compressor attains an efficiency of approximately 85 per cent. Fig. 4 is a view of the compressor with the cover removed, showing the blading arrangement.

A section through one of the combustion chambers is shown in Fig. 5. Here the air from the regenerator at 750 F is further heated by the burning of fuel directly in the air stream. The form of the combustion chamber and the use of the air-cooled flame tube make unnecessary the use of brickwork, hence the unit responds quickly to load changes, during which the power demands are met by the opening or closing of two fuel valves. The present unit is operating with No. 2 furnace oil, but in an ultimate installation it is contemplated that fuels of grades as low as Bunker C oil will be used.

The turbine driving the compressor is substantially the same as the power turbine, except that the former has somewhat longer blades and is provided with an air-operated internal bypass which is opened when starting. Each turbine has five pressure stages and operates at 5200 rpm at full load. The first two stages are of the impulse type and the last three of the reaction type. A diaphragm carries the nozzles that separate the first and second impulse stages. Fig. 6 shows the turbine rotor being lowered into the casing.

For cooling the face of the high-temperature turbine wheel, air is carried through the outer of the two cooling tubes to a disk adjacent to the side of the high-temperature wheel; and a series of holes in the periphery of the stationary disk directs the air to the side of the first-stage turbine wheel. The cooling air then passes radially inward over the side of the disk and then out the center pipe to a water-cooled heat-exchanger from which it is returned to the outer cooling duct by a positive-pressure blower. In like manner cooling air is introduced around the periphery of the second-stage diaphragms.

The blades and disks of the turbines are constructed of a recently developed high-temperature Timken alloy steel which includes 16 per cent chromium, 25 per cent nickel and 6 per cent molybdenum. The heavy stationary parts of the turbines are made of an alloy steel containing 25 per cent chromium and 12 per cent nickel.

Piping

In order to handle the vast quantities of air and hot gases involved in a unit of 3500 hp capacity, very large pipes are necessary, despite the rather high velocities. This will be apparent by reference to Fig. 1 which shows the inlet ducts to both turbines. The air intake pipe is

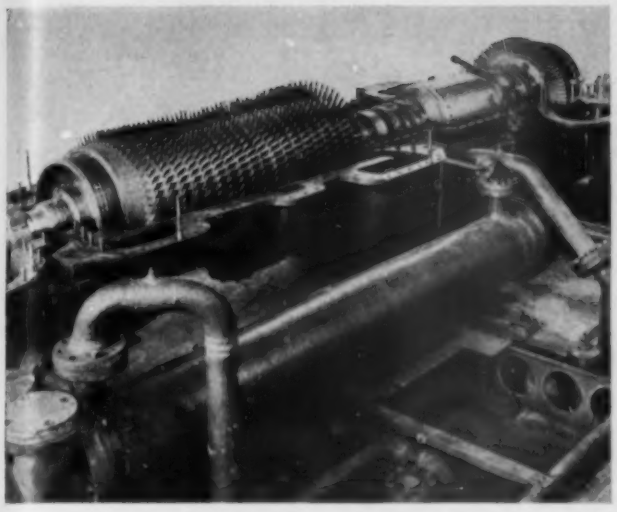


Fig. 4—Compressor with top half of casing removed

36 in. inside diameter and the exhaust opening of the gas-generator turbine driving the compressor is 42 in. diameter. The high-temperature piping is designed with an inner skin, or gas conducting member, over the walls of which there is no pressure difference. Mineral block insulation between the inner and outer walls establishes the temperature drop whereby the outer wall is cooled sufficiently to maintain the necessary physical strength. The pipes leading from the combustion chambers to the turbines appear unusually large because the insulation necessary to withstand the hot gases at 1500 F is inside between the double wall construction.

In the large high-temperature piping an internal gas-guiding tube is installed with a space of approximately 9 in. between the internal guiding wall and the outside of the pipe. This space is filled with mineral block insulation.

The swing-type expansion joints installed in the piping are of major importance due to the thermal expansion that takes place between room temperature and the high initial temperature at which the unit operates. These joints consist of a series of radially placed hinges between the flanges, the arrangement being such that the rotation of the adjoining members operates to relieve the dimensional changes of the piping resulting from thermal expansion; thus obviating distortion of the turbine and compressor parts.

Since a gas turbine must be started with external power, an electric motor is connected to the compressor unit by a clutch for use up to a starting speed of 25 to 35 per cent of full load speed. The starting motor is disengaged when the firing speed is reached and the fuel in the combustion chamber is ignited. Less than 100 hp is required to start the unit.

Tests at Increasing Temperatures

The test plans for this unit included operation for established periods under prearranged operating conditions with gradually increasing inlet temperatures. Each test operating period was then followed by a complete disassembly and full inspection with numerous measurements to determine what changes with high-temperature parts have taken place. The examinations have included thorough search for development of any cracks and also observations of the resistance to oxidation. Obviously, this procedure consumed considerable time.

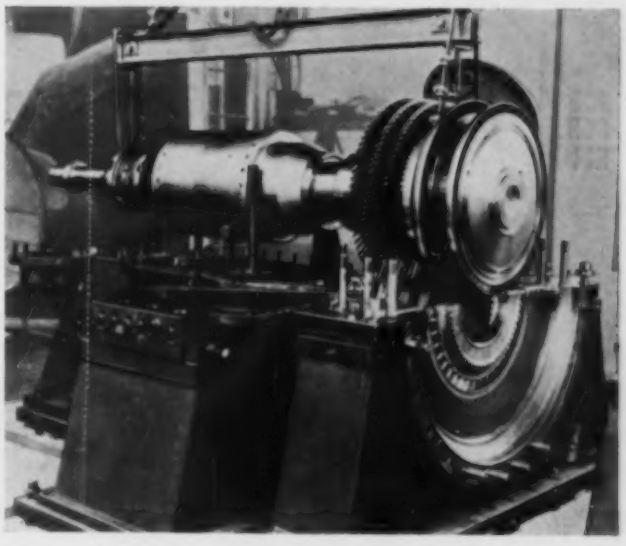


Fig. 6—Turbine spindle being lowered into casing

A set of runs was first made with the compressor at 40 per cent full load, followed by gradual increases up to full speed with the gas-generator turbine inlet temperature up to 1050 F. Then the temperatures were gradually increased, making complete tests at each new level, until recently when the power turbine was run at full speed and at 1350 F. Both turbines were operated in November for over 50 hr at full speed of 5200 rpm, with 1200 F inlet temperature on the power turbine and 1100 F on the gas-generator turbine. In fact, up to the end of March the unit had operated 500 hr. According to the present schedule it is hoped to have the unit tested at 1500 F by late summer.

Until completion of the tests, and pending release by the Navy Department, the detailed test results are of a restricted nature, but it is anticipated that, eventually, a complete report will be made available.

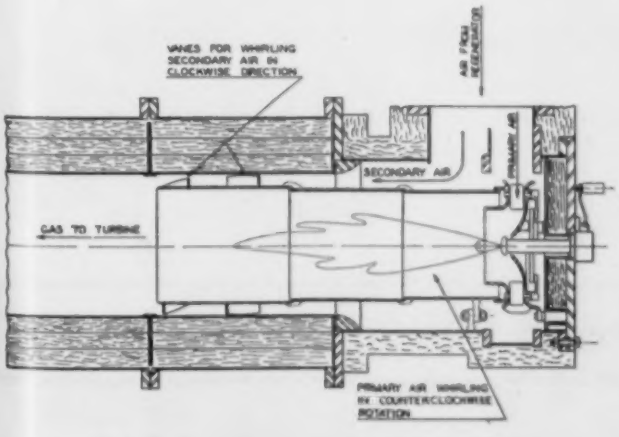
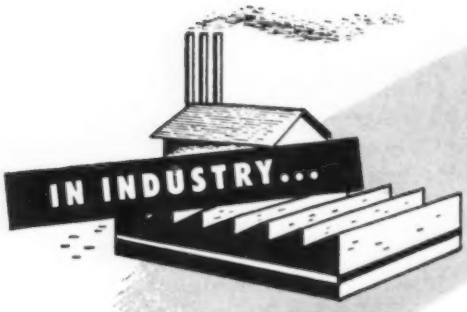

VANES FOR WHIRLING SECONDARY AIR IN CLOCKWISE DIRECTION
AIR FROM REGENERATOR
SECONDARY AIR
PRIMARY AIR
GAS TO TURBINE
PRIMARY AIR WHIRLING IN COUNTERCLOCKWISE ROTATION

Fig. 5—Section through combustion chamber



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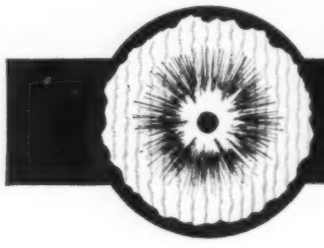

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Combustion Control at University Power Plant

THE University of North Carolina, founded 150 years ago, was the first state university to be established. Provision for it was contained in the constitution adopted by that state at the close of the Revolution and a site was chosen in the center of the state near an old chapel of the Church of England; hence the name "Chapel Hill." The University was opened in 1795.

The power plant of the University supplies various services, including a sizable electric load, steam for heating in winter, for a large amount of hot water in the dormitories and gymnasiums, for the laundry and for the hospital and campus hotel. In summer the average steam requirements amount to around 25,000 lb per hr, whereas in winter this is stepped up to 75,000 lb per hr. Because of the nature of the services the load varies widely.

To provide adequate power and steam for the growing demand, the University began scrapping its o'd boiler plant in 1940 and started work on a new power plant. This called for the installation of two pulverized-coal-fired Combustion Engineering VU type steam-generating units of 70,000 lb per hr each continuous rating at 425 psi at the superheater outlet and 725 F total steam temperature. The boilers have completely water-cooled furnaces with plain tubes on the front, sides and roof, and each is fired by two Type R horizontal burners. They are equipped with Ljungstrom air preheaters and Elesco interbank superheaters, and three Raymond bowl mills serve the two boilers.

Electric power is furnished by a 2500-kw Elliott condensing turbine-generator provided with extraction points at 75 psi and 25 psi. The latter, which is automatically controlled, supplies the steam for heating throughout the campus whereas the former, under manual control, serves to make up any deficiencies of the 25-psi extraction. About 90 per cent of the steam is returned to the boilers as condensate, and the longest run of steam-heating pipe is about 5000 ft.

Because of wide variations in load, the boilers were equipped with automatic combustion control. This is of the air-operated Hagan type regulating the coal feed to the mills and primary air damper. Operation of the control is simple and is essentially as follows:

The impulse from one compensating relay is imposed on the diaphragm of a receiving regulator which controls the lever on the variable speed drive of the pulverizer feeder. This regulator positions the lever of this drive so that the proper amount of coal will be fed to the mill for each boiler load. The impulse from a second relay is connected to the primary air damper of the pulverizer. In this manner the damper is properly located for each boiler load. The compensating bars on these regulators provide the means of calibrating the regulators in the field so that the exact movement desired of the regulator for each loading may be obtained.

The master impulse, at the same time that it is to be transmitted to the fuel feed controllers, is also imposed on the bellows loading of the double diaphragm sender. Should master loading call for an increased air flow, the sending pressure from this diaphragm sender changes so that air flow to the boiler is increased. This increase remains in effect until air flow balances master loading.

The impulse from the diaphragm sender is transmitted to a manual control station located on the panel board which gives the operator a means of placing the forced-draft damper under manual control. The impulse is then transmitted to a receiving regulator directly connected to the forced-draft fan inlet vanes which are moved by the regulator until correct forced-draft air flow is established.

To maintain furnace draft constant, a diaphragm regulator is installed, operating through a relay on the panel board to control a receiving regulator connected to the induced-draft fan dual drive speed controls in combination with close damper control.

The plant was designed by W. C. Olsen, of Raleigh, N. C., as consulting engineer.

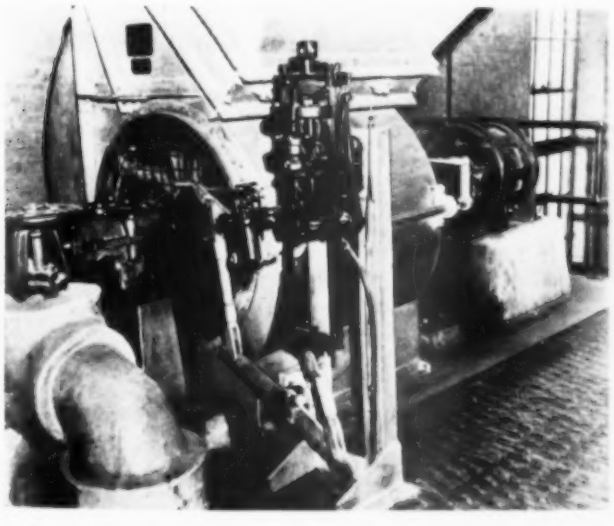


Fig. 1—Forced-draft fan with receiving regulator connected to the inlet vane control

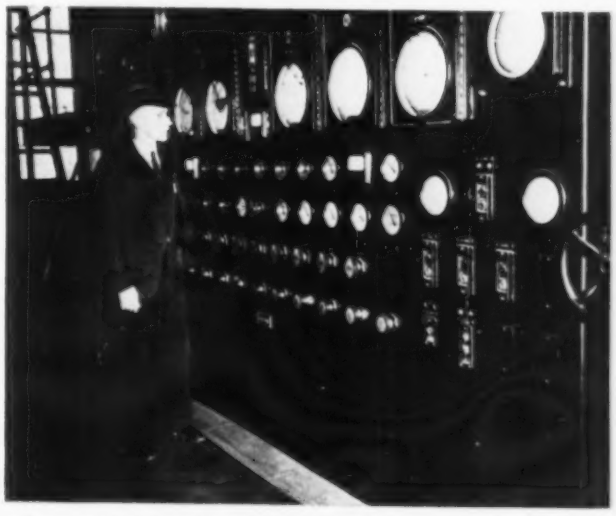


Fig. 2—Chief engineer, H. I. West, observes the master control panel

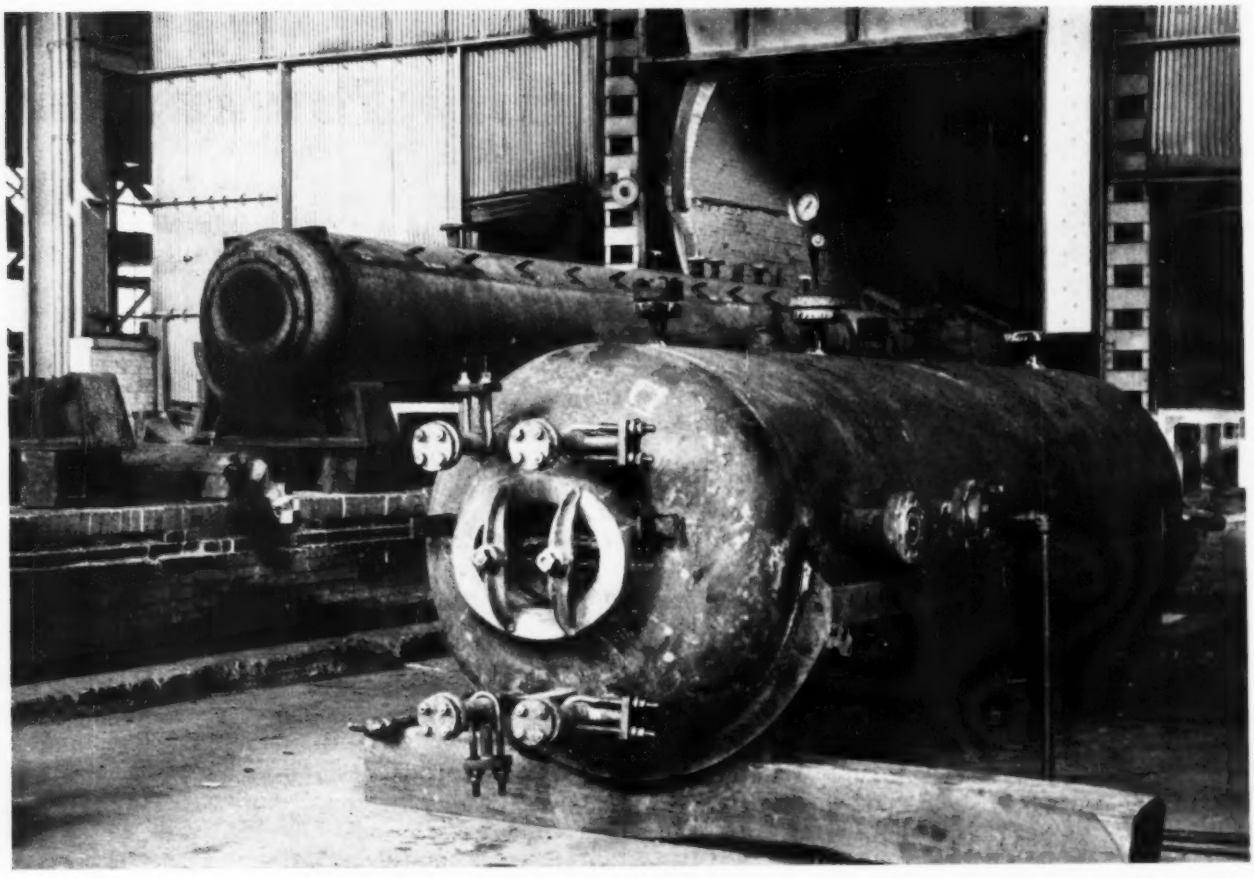


Fig. 1.—Hydrostatic test set-up for highest pressure marine boiler drum ever built. Two flanges remain to be blanked. Pressure gage and test pressure pipe are connected. Drum is designed for 1535 psi. Drum on car in background is ready to enter furnace for stress relief.

THE FABRICATION OF BOILER DRUMS
Part 3—Testing and Finishing

This article describes the normal testing and finishing procedure used in connection with the fabrication of boiler drums at the Chattanooga plant of Combustion Engineering Company, Inc. Previous articles of the series appeared in the March and April issues.

By H. R. TOWSE
Combustion Engineering Company, Inc.

Photographs by author and by Metallurgical Department

THROUGHOUT the process of fabrication of a boiler drum, the parts which will be subjected to stress are under scrutiny of one kind or another. Four methods of checking are used, based on the procedure approved by the Power Boiler Code of the American Society of Mechanical Engineers.

Inspection

1. Inspection starts with the delivery of the plate from the rolling mills and continues at every stage of fabrication thereafter until the finished product leaves the plant. This is done by experienced shop men and by an insurance company inspector qualified for inspecting boilers for the particular state or municipality in which the boiler is to be installed. In addition to the visual inspection of the plate itself, each machine operation is checked by the foreman in charge. Under special conditions or circumstances, other methods of examination, which are not in the normal procedure, are available for use on specification, such as complete examination by chemical analysis, heat treating and micro-photography. Also for examination of plate edges prior to welding and

other parts which are not X-rayed, a Magnaflux machine and Supersonic Reflectoscope may be used.

Physical Testing

2. Physical testing is conducted on test samples of thicker plate at the completion of the forming operation and on specimens of the welded test plates at the completion of the longitudinal seam weld. The bend-test specimen of the welded joint is required to be transverse to the welded joint of the full thickness of the plate and of rectangular cross-section with the width $1^1/_2$ times the thickness of the specimen. The inside and outside surfaces of the weld are required to be machined to a plane surface flush with the plate, with the edges of this specimen rounded to a radius not over 10 per cent of the thickness of the plate. The specimen is bent cold under free bending conditions until the least elongation, measured within or across approximately the entire weld on the outside fibers of the bend-test specimen, is 30 per cent.

When a crack is observed in the convex surface of the specimen between the edges, the specimen is considered to have failed and the test is stopped.

One tension test is required of the welded joint and one of the weld metal. The joint specimen is cut so that the direction of the weld is across the specimen which is required to be the full thickness of the welded plate after the inner and outer surfaces have been machined flush with the plate. The tensile strength of the welded joint is required to be not less than the minimum of the specified tensile strength range of the plate.

The tension-test specimen of the weld metal is required to be taken entirely from the deposited weld metal and its tensile strength must be at least that of the minimum range of the plate which is welded and its elongation in 2 in. must be at least 20 per cent.

If necessary, on account of limitations in the capacity of the testing machine, the Code allows the bend and transverse tension specimens to be cut with a thin saw into as many portions of the thickness as necessary, each of which shall meet the requirements.

Radiographic Examination

3. Radiographic examination of welds furnishes a very valuable method for non-destructive testing of metal within the limitations of its applications. The method is applied to welds to ascertain the soundness of both the weld and the adjacent metal. It shows defects such as gas cavities, slag inclusions, unsatisfactory penetration, imperfect fusion and cracks. Equal spaces are marked

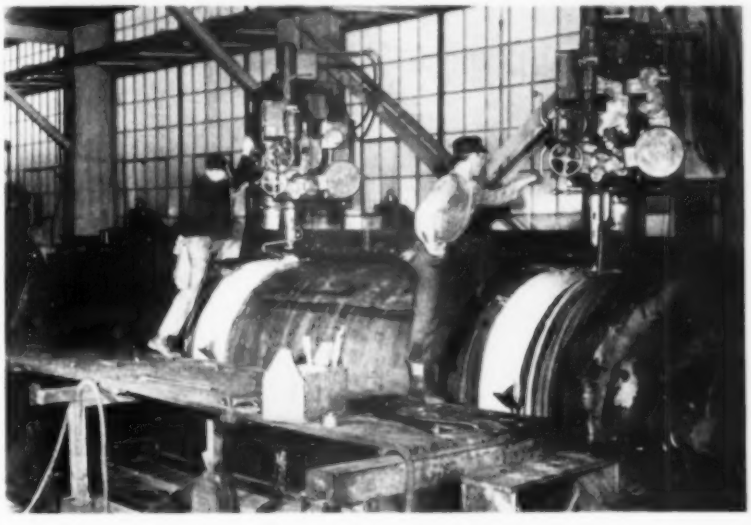


Fig. 3 (below).—Close-up of tube-hole drilling operation; showing jig which is used to assure accuracy of alignment

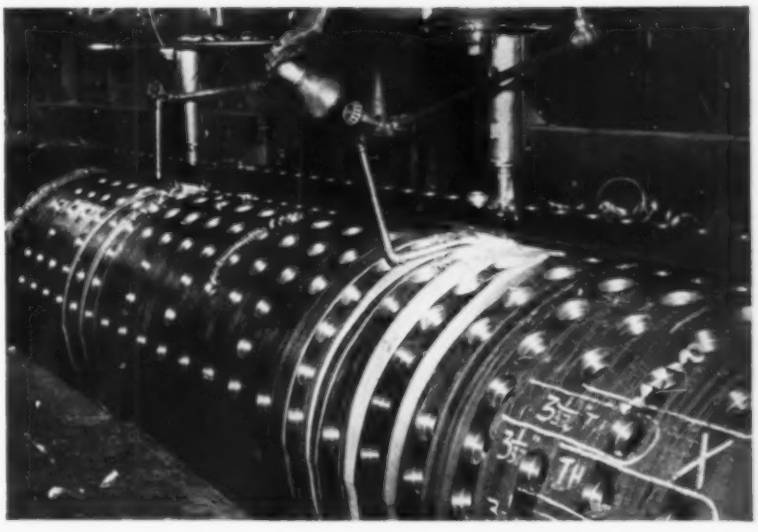


Fig. 2 (above).—Radial drill presses are used for drilling and reaming tube holes. Drilling jig is in position

Fig. 4.—Radiograph showing porosity

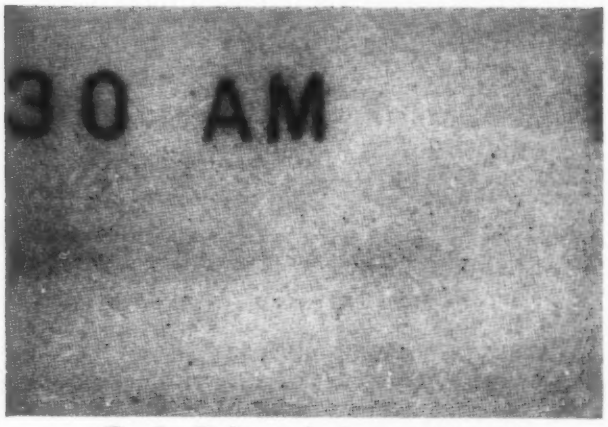


Fig. 5.—Radiograph of acceptable weld

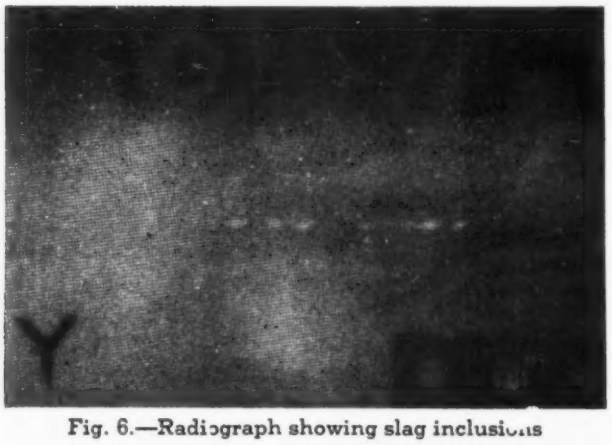


Fig. 6.—Radiograph showing slag inclusions

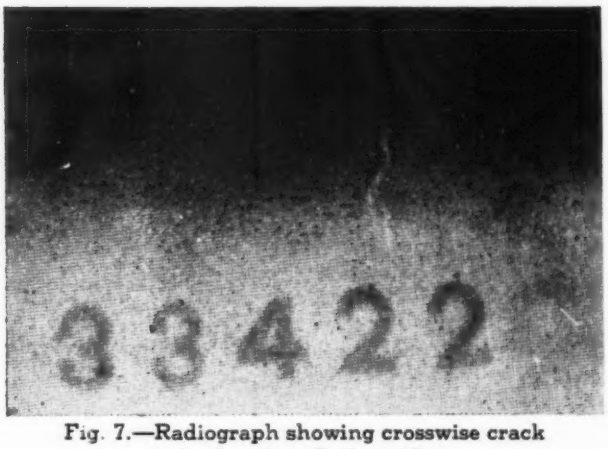


Fig. 7.—Radiograph showing crosswise crack
(made without Buckey grid)

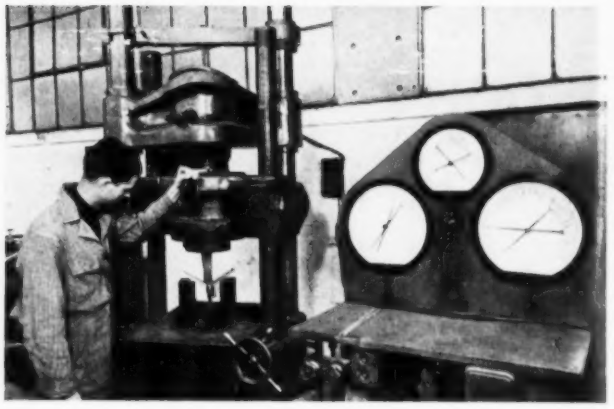


Fig. 8.—Start of bend test

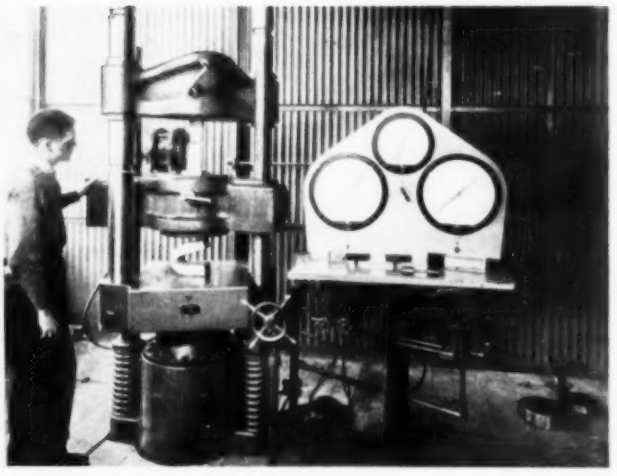


Fig. 9.—Tension test has been completed on specimen in upper part of machine; bend test is being made in lower part

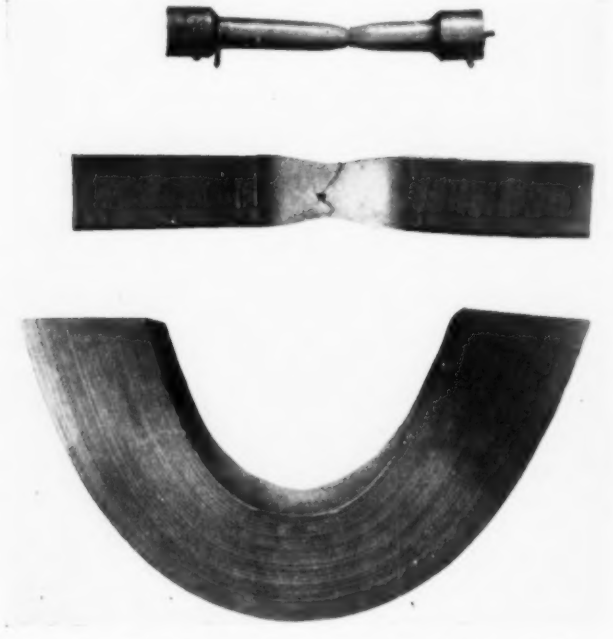


Fig. 10.—Physical test specimens after testing. Upper —all-weld metal tension; center—joint tension; lower—bend.

(Photographs on this page furnished by Metallugical Dept.)

off on the seams and numbered consecutively. The numbers are stamped on the drum for a permanent record. Each film bears two consecutive numbers, one at each end and as each picture overlaps those preceding and following, each number appears on two films, thereby assuring examination of the entire seam.

In addition to being a reliable indicator of the soundness of boiler drum welds for purposes of acceptance, radiographic examination is also used in connection with the development of welding procedures, the training and examination of welding operators and shop control of weld quality.

As a check on the radiographic technique, the Code requires that suitable thickness gages, called penetrameters, shall be employed to detect defects of a thickness equal to and greater than 2 per cent of the thickness of the base material.

The material of the penetrameter is required to be substantially the same as that of the plate under examination and the thickness must be not more than 2 per cent of the thickness of the plate. Three holes are required in each penetrameter, the diameters being, respectively, two, three and four times the penetrameter thickness, but in no case less than $^1/_{16}$ inch. The smallest hole and the identifying numbers must be distinguishable on the radiograph. Two sizes of penetrameters are required; one, $1^1/_2$ inches long and $^1/_2$ inch wide for plates up to and including $2^1/_2$ inches thick, and the other, $2^1/_4$ inches long and 1 inch wide for plates over $2^1/_2$ inches thick.

Two penetrameters are required for each exposure, one at each end of the exposed length on the side of the plate which is nearer the source of radiation. They must be parallel and adjacent to the weld seam with the small holes at the outer ends.

During exposure, the film is held as close as possible to the surface of the weld on the side farther from the source of radiation. When the film is not more than 1 inch from the surface of the weld, the Code specifies the minimum distances between the other weld surface and the source of radiation as follows:

Plate Thickness	Min. Dist. From Source of Radiation to Radiation Side of Weld
Up to 1 in.	14 in.
1 to 2 in.	21 in.
2 to 3 in.	28 in.
3 to 4 in.	36 in.
4 to 5 in.	38 in.

If it is necessary to expose the film at a distance greater than 1 inch from the weld, the Code requires the ratio:

$$\frac{\text{Distance from source of radiation to weld surface toward radiation}}{\text{Distance from weld surface toward radiation to film}}$$

to be at least 7 to 1 except that when a grid of the Buckey type is used to reduce scattered radiation, the ratio may be reduced to 5 to 1. The Code states that these conditions are imposed so as to obtain a practical maximum allowable distortion and magnification of any defects in the welded seam.

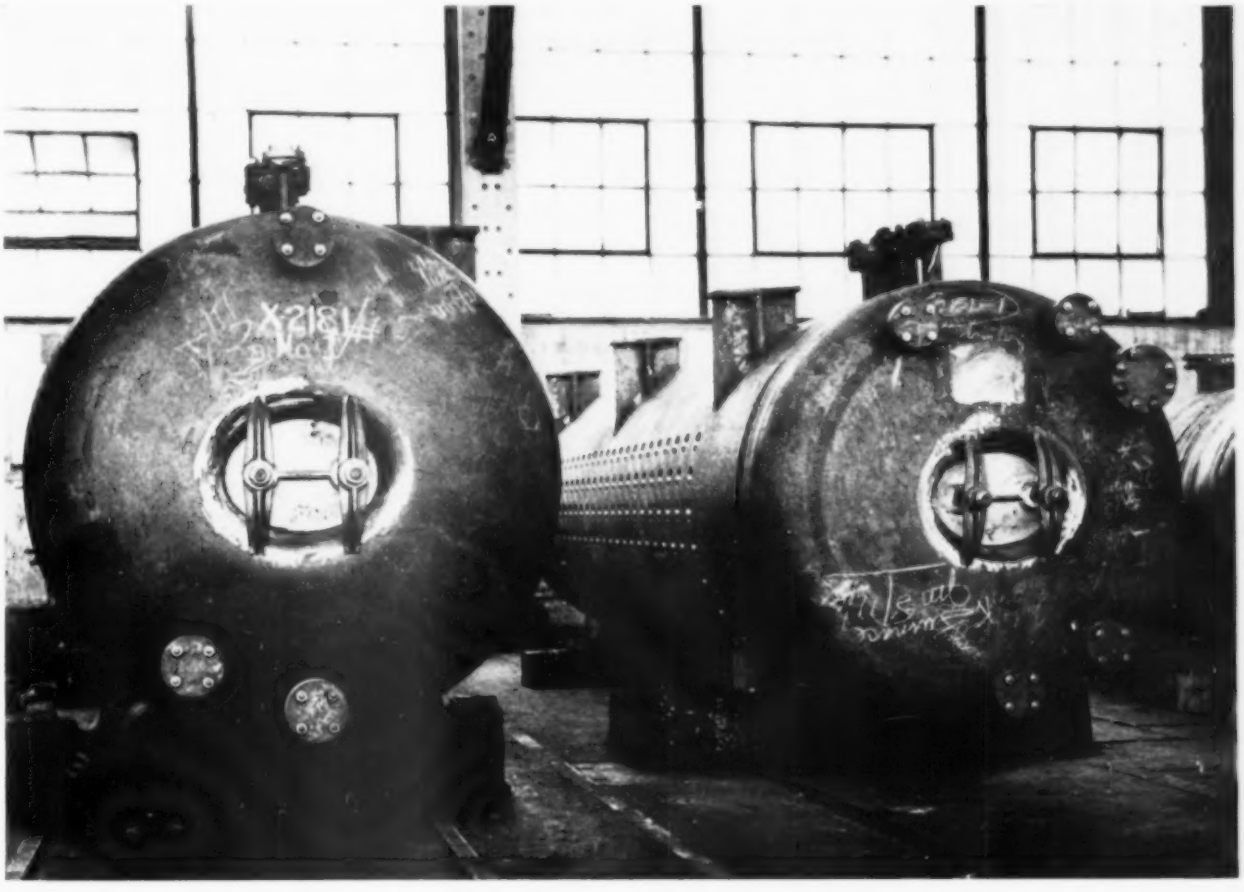


Fig. 11.—Completed drums ready for painting; superheater support brackets shown on right-hand drum

When the X-ray tube is operated at a voltage of 1000 kv or more and the Buckey grid is used on plates 3 in. or more in thickness, the foregoing specifications on technique may be modified in order to suit the particular requirements.

The acceptability of welds examined by radiography is judged by comparing the radiographs with a standard set of radiographs, reproductions of which may be obtained by purchase from the American Society of Mechanical Engineers.

Hydrostatic Test

4. After the stress-relieving operation, the welded drum is prepared for the hydrostatic test. Manhole plates are fitted, the pressure gage and feed line are connected and all remaining nozzles are blanked. The water used for testing is required to be not less than the temperature of the surrounding atmosphere and in no case less than 70 F. The rising pressure is kept under proper control so that the required test pressure is not exceeded by more than 6 per cent.

Drums are tested to either $1^1/_2$ or 2 times the maximum allowable working pressure (also known in the trade as "stamping pressure"), depending on the limitations of design stresses approved by the Code as of July 18, 1945. The hydrostatic test is witnessed by an insurance inspector, as specified.

Finishing

The drum is now ready for the finishing operations. If required, it is shot-blasted or sand-blasted, as specified, otherwise it goes directly from the hydrostatic test block to a face plate for tube hole layout. Here again, the shop inspectors carefully check the work that is being done.

The next operation is to drill and ream the tube holes, grooving them where required. A battery of radial drill presses is available for this work. Jigs are used during the drilling operation to assure accuracy in alignment. Then the drum is cleaned and tube holes are chamfered with revolving cleaners driven by air motors. At this point, there is an internal inspection by a representative of the insurance company, as specified. Drum internals are then installed and if required, drum chairs are fitted.

Final Inspection

The drum is now ready for inspection by an authorized C-E inspector and if desired, the customer may also make inspection. Upon approval by the inspectors, the tube holes are greased and capped and the drum is painted for protection during shipment and the subsequent handling.

After a final check by C-E inspectors, the drum is stamped near and above the manhole opening with the A.S.M.E. Code Symbol and identifying information such as the serial number and name of the manufacturer, year built, heating surface and maximum allowable pressure when built. The drum is then ready to be loaded for shipment to the customer's plant, where it will be erected as part of the assembly of a C-E boiler.

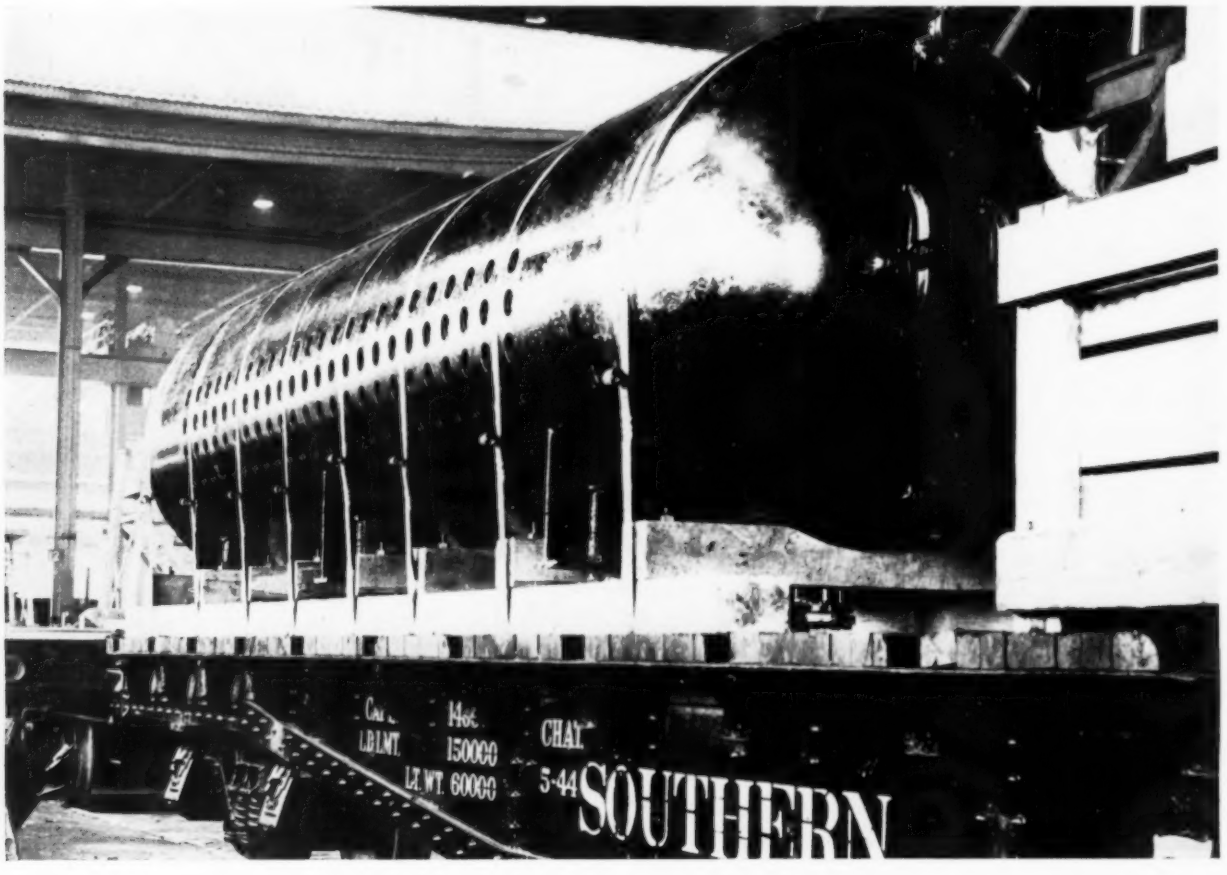


Fig. 12.—Completed boiler drum ready for shipment

Reduction of Turbine-Blade Deposits by Water Conditioning

In this paper presented at the recent Midwest Power Conference, the authors relate experience of excessive turbine clogging from water-soluble and insoluble deposits with the 1300-psi high-makeup installation at Commerce Street Station, Milwaukee. The insoluble silica deposits have been reduced about 90 per cent by internal boiler treatment with magnesium oxide, in the absence of phosphate; and simultaneous internal treatment with barium chloride is used for sulphate reduction. Carbonaceous zeolite softeners allow operation with extremely low calcium in the makeup for assurance against boiler scale formation.

By M. E. FITZE and F. H. LONG

Wisconsin Electric Company

THE 35,000-kw, 1200-psi, 900-F tandem-compound turbine installed at the Commerce Street power plant of the Wisconsin Electric Power Co. in 1941 replaced six engines of an aggregate capacity of 10,000 kw that had been installed over the period of 1903 to 1905.

This station is the principal source of steam for the company's central heating system on the west side of the Milwaukee river. To take advantage of the obvious economies of by-product power generation, the new unit was arranged for bleeding to the three-pressure heating system.

There are four stages of extraction heating to provide feedwater at 390 F. The fourth stage is bled in addition to feedwater heating to provide steam for the high-pressure heating system as well as for a 150-psi line that serves as a "booster" to the low-pressure system in the center of the downtown area. This fourth extraction point also provides steam for the turbine-driven boiler feed pumps, exhaust from which is normally routed to the low-pressure heating system. They can, however, exhaust to the Court House main if necessary.

The third- and second-stage extraction points are interchangeably used as load and pressure conditions require to provide steam for the Court House lines and the low-pressure downtown heating system. An end pressure of 20 psi is maintained on the Court House line and 5 to 6 psi on the low-pressure system. The first stage extraction point is under vacuum, so is used only for feedwater heating.

In addition to the four points mentioned, a fifth extraction point is provided above the fourth to serve the high pressure heating system at times when the electrical load is too low to maintain sufficient pressure at the fourth point.

A maximum of 240,000 lb per hr of bled steam to commercial heating is contemplated in the design which with blowdown amounts to some 60 per cent makeup. Under such maximum conditions of bleeding, electrical capacity is reduced to around 24,000 kw.

The condenser "floats" on the exhaust, receiving only such steam as is not bled off for feedwater heating and commercial steam requirements.

The turbine is served by a 375,000-lb per hr, three-drum boiler equipped with a combination radiant and convection superheater. There is no reheat.

In choosing a water treatment system for such high makeup, high feedwater temperature and high boiler pressure, many factors had to be considered. Success had been had at another high makeup plant on the Company's system with a hot-process lime-soda softener. This other plant, however, operates at 650 psi. It was felt that the more stringent conditions at Commerce Street required lower hardness to avoid feed-line deposits and lower soluble solids as a margin against feed-line corrosion and boiler carryover, than could be obtained from a hot-process softener; and besides, space for a hot-process softener would have been difficult to arrange. A carbonaceous zeolite softener therefore was chosen despite the fact that no reduction in silica is obtained as with the hot process. A more favorable heat balance arrangement and simpler piping layout were also possible. Furthermore, vacuum degasification at pH 4 afforded reduction of CO_2 in the steam to less than 1 ppm, and final automatic pH adjustment with NaOH, afforded a minimum of excess alkalinity. Final internal treatment with phosphate in the conventional manner was anticipated in the initial plan.

Initial Turbine Deposit Trouble

From the very beginning of high makeup operation turbine blade deposits were a serious problem. Deposits followed the usual pattern found in high-pressure machines, namely, water-soluble type in the higher pressure zones and the hard, tenacious, insoluble silica deposits toward the lower end. In general, stage pressures increased from deposits at a more rapid rate as the percentage of makeup increased, but there were occasional periods in which the opposite was true for no apparent reason.

Blowdown regulation to a constant percentage of makeup afforded a rather constant composition of boiler water, which eliminated the possible effect of varying concentrations. A few organic determinations by ether-extraction showed no apparent abnormality.

Carryover measurements of the steam by conductivity indicated insufficient accuracy for reliable conclusions,

due to the difficulty of correcting for the usual noncondensable gases. Also, lack of a reliable tool for determining total solids in the steam with reasonable rapidity, made it difficult to correlate the effect of changes in boiler-water treatment without waiting for stage pressure readings over a period of several days or weeks.

Using stage pressures as a guide, several trial attempts were made to alleviate carryover by treatment of the boiler water with different types of suspended material, such as sodium chloride, sulphite and sulphate, but none seemed to help.

To try to alleviate insoluble silica deposits, NaOH was tried at about double the SiO_2 hoping that the silica would remain in the water-soluble silicate form and thus be removable by water washing. This proved not to be the case, so the trial was abandoned due to more rapid clogging in the high-pressure end.

Turbine washing was practiced whenever stage pressures showed the need for it, which was about once a month at high makeup loads. While water washing was satisfactory for removing the soluble deposits, caustic washing afforded only partial removal of the insolubles.

This constant recurrence of turbine clogging despite known low values of carryover, focused attention on the problem of silica removal since experience had so thoroughly demonstrated that there was no apparent treatment or combination of treatments that would prevent the actual vaporization of silica directly from the boiler water to the steam at the temperatures existing in a 1300-psi boiler.

Adaptation of the silica determination to extremely small concentrations made it possible for the first time to get an idea of just how much silica was being deposited on the turbine blading and promptly to evaluate changes made in treatment. Samples of steam were taken at the outlet of the convection superheater, condensed in a stainless steel coil and compared with simultaneous samples of hotwell condensate. Lower silica in the hotwell than at the superheater outlet indicated placing of silica deposits on the turbine blading. Considerable experience has been had indicating the method to be reliable. Silica values in the steam were found consistently proportional to silica in the boiler water and the effect of changes made in boiler treatment were detected within half an hour to an hour after the change. It appeared that, within limits of accuracy of the test, there was a tolerance of around 1.5 to 2 ppm silica in the boiler water without turbine deposits becoming too objectionable. Since there seemed to be no magic suppressive agent for silica, if such deposits on the turbine blading were to be prevented, the silica had to be definitely eliminated, especially under 1300-psi conditions.

Silica Removal by Magnesium

Use of magnesium for prevention of turbine deposits had been tried twice previously at this station in connection with other treatments, both in the form of sulphate (Epsom salts) and as the oxide, but in the presence of phosphate they were found wholly ineffective and were abandoned. It had been found that the magnesium oxide reacts with the phosphate first until the phosphate is practically eliminated, before any reduction in silica occurs. Later it was decided to try magnesium in the absence of phosphate with the hope that calcium scale could be prevented in the final scheme.

Since some difficulties were already being experienced with deposits of sulphates in radiant superheater tubes, further increase of sulphates in the boiler was felt undesirable, and precluded the use of magnesium sulphate.

The first trial of magnesium oxide for silica removal in absence of phosphate was made in December 1944. As the phosphate was decreased preparatory to adding magnesium oxide, there was a definite drop in all the silica values, apparently due to the small amount of residual magnesium in the water after the softeners. Addition of magnesium oxide resulted in an immediate and large reduction in silica. An equilibrium value of slightly over 2 ppm SiO_2 was reached in the boiler representing a 5:1 reduction. The magnesium oxide was fed intermittently on the basis of $^1/_8$ lb per 5000 gal of makeup. This amounted to 3 ppm of magnesium oxide based on makeup in which SiO_2 is quite constant at 3 ppm. Silica in the steam was around 0.05 ppm with only a trace deposited on the turbine blading.

This trial run which covered a period of 18 hr, gave an indication of the possibilities of this method of silica reduction. The absence of phosphate, however, led to the fear of scale formation due to slight residual calcium in the makeup water. Consequently, the next trial run was made with phosphate present in sufficient amount to precipitate about 3 times the amount of calcium estimated in the makeup water. Although the length of this run was about one month, it was during only the latter half that treatment conditions were held practically constant and allowed a fair approach to equilibrium. For that half month the following rates of treatment were applied intermittently every 10,000 gal of makeup.

Treatment	Lb per 10,000 Gal	Ppm (Makeup Basis)
Magnesium oxide	0.25	3.0
Monosodium phosph.	0.40	4.8
Organic dispersive agent	0.14 (dry wt.)	1.7
Boiler water concentrations were		
NaOH		4 ppm
Na_3PO_4		2 ppm
Na_2SO_3		110 ppm
NaCl		28 ppm
Na_2SO_4		3 ppm
SiO_2		7.3 ppm
Suspended		10

It was evident that even at low concentrations of excess phosphate (2 ppm Na_3PO_4) in the boiler water, very little of the magnesium oxide was available for silica removal. A chemical balance indicated that 77 per cent of the magnesium oxide was used up by phosphate while the other 23 per cent removed $1^1/_4$ times its weight of silica.

During this run, No. 2 bleeder pressure, which indicates insoluble silica deposition, increased imperceptibly compared to a 3 per cent per day increase after stoppage of the magnesium oxide and resumption of former high silica values.

The desirability of obtaining lower silica than would be practical in conjunction with phosphate, prompted discontinuance of phosphate. Subsequently the rate of magnesium oxide treatment was regulated to allow approximately 2.5 ppm SiO_2 in the boiler water.

The effect of a further increase in magnesium oxide is shown in the following tabulation:

MgO, Ppm	Boiler Water SiO_2, Ppm, Avg.	Per Cent Blowdown (of Makeup)	Ratio, Ppm MgO ÷ Ppm SiO_2 Removed
3.6	2.5	22.1	1.6
4.8	1.8	16.5	2.0

It will be noted that the 1.2 ppm increase in MgO

removed only 0.25 ppm SiO_2, calculated no the makeup basis, or a ratio of 5:1, whereas the total overall ratio is about 2:1. This difference is indicative of the adsorption principle which is characteristic of this reaction.

The above data were obtained during low makeup operation. A comparison of MgO to SiO_2 ratios at high and low rates of makeup is as follows:

Makeup, Per Cent	Per Cent Blowdown of Makeup	Ppm SiO_2 in Boiler	Ppm MgO in Makeup	Ratio, Ppm MgO ÷ Ppm SiO_2 Removed
9	17.7	1.8	4.8	1.8
45	13.8	1.9	7.2	2.6

The increased ratio at the higher makeup is apparently a function of the time variable in the adsorption process

The reduction of silica in the boiler water to around 2 ppm has continued for almost a year, and has effected a corresponding reduction in turbine clogging as indicated by No. 2 bleeder pressure.

Barium for Sulphate Reduction

A companion difficulty along with turbine-blade deposits has long been the deposition of solids (largely sulphates) in the radiant superheater. One tube failure was caused by this and periodic week-end outages for boiling out were required. It was therefore felt desirable to try reduction of sulphate in the boiler water along with magnesium treatment. The first trial was made with barium hydroxide, to precipitate the sulphate as barium sulphate, thereby reducing the amount that could be carried over from the boiler. Results showed a fair reduction in sulphates, but the amount was not thought large enough to be worth while; so in view of the sharp increase in alkalinity (from using barium hydroxide) which would increase the water-soluble deposits in the high-pressure end of the turbine, the trial was abandoned. A later trial of barium chloride proved successful.

Immediately upon use of the barium chloride, the sulphate in the boiler water dropped and the chloride increased in equivalent proportion.

The use of barium has continued for about $8^1/_2$ months in conjunction with magnesium oxide at a constant rate of 30 ppm $BaCl_2$-$2H_2O$ in the makeup, affording 50 to 60 per cent reduction in sulphate.

Many operating variables make quantitative comparison of superheater deposits before and after barium treatment of questionable value. Superheater wash water analyses have always shown predominance of sulphate with very little chloride. Since using the barium chloride, chloride in the wash water has not increased, indicating the higher chloride in the boiler water to be not harmful. Turbine-stage pressure readings before and after the use of barium chloride confirm this.

The chemical treatment (including MgO and $BaCl_2$) for this boiler has so far been applied intermittently with a pot feeder delivering to the feed line just after the last extraction heater. Deposits of barium sulphate found in the feed line and on check valves necessitated its discontinuance until means can be had for injecting it direct to the boiler. It is also desired to find out if its discontinuance will lessen plugging of rear row boiler tubes, though this is hardly to be expected since these rear tubes are in a region of sluggish circulation and some clogging has long been experienced.

Effect of Magnesium Oxide and Barium Chloride Treatment on Internal Boiler Deposits

The first major trial of magnesium oxide for silica reduction was made in the presence of some phosphate. This was prior to the use of barium chloride and continued for about a month after which the boiler was opened for inspection.

Internal inspection showed nothing unusual except some thin, nonadherent egg-shell type scale about 0.005 in. thick that shelled off when the boiler cooled down. This scale was located mostly in the downcomer tubes from the mud drum to the rear screen header. Chemical and X-ray analysis showed it to be a mixture of hydroxyapatite and magnesium hydroxy phosphate, the latter predominating. Sludge deposits were not large nor did it appear that they might become troublesome. Front wall tubes are, of course, subject to maximum rates of heat transfer, but turbining of two sample tubes yielded nothing in the way of deposits that would be in any way alarming. Some rear row boiler tubes were entirely clogged, but the nature of the deposits were such as to prove them to have originated during other previous trial runs and had no bearing on the use of magnesium for silica reduction.

Analysis of five samples collected from various parts of the boiler showed the following:

	1	2	3	4	5
Loss on ignition	4.40	5.43	4.42	5.62	7.18
Silica	2.87	3.96	3.73	1.89	11.90
Iron (Fe)	1.93	29.60	27.10	4.88	7.12
Copper (Cu)	None	2.76	15.75	None	0.96
Phosphate (PO_4)	52.60	27.26	13.82	50.15	36.19
Calcium (Ca)	8.45	2.34	2.88	12.39	2.36
Sulphate (SO_4)	0.30	0.90	1.50	2.04	2.04
Magnesium	19.40	3.14	4.25	15.06	27.80
Aluminum	0	0	0	0	0

Samples:
No. 1 = Egg-shell scale chips from bottom of screen drum
No. 2 = Turbinings from front wall tube
No. 3 = From lower end of plugged row of tubes
No. 4 = Rear drum deposits (soft) on rear several rows of tubes
No. 5 = Light powder deposit from lower end first-pass tubes

Three of the five samples were subjected to X-ray analysis. Since the egg-shell scale deposits were found to be magnesium hydroxy phosphate, and also the fact that phosphate caused the silica removal efficiency to be low, the use of phosphate was gradually diminished over a period of three weeks and then stopped entirely. Subsequent to the stoppage of phosphate it was found possible to reduce the rate of magnesium oxide and still maintain the silica at 2 to 3 ppm.

The egg-shell scale chips previously referred to have been found in the boiler on each subsequent inspection. Their formation on the rear downcomer tubes has not continued, but their presence is explained as being dislodged from the other surfaces such as drum walls, baffles, etc., apparently at times of temperature change. Analysis has always shown them high in phosphate, indicating them to have originated during the early use of the magnesium and oxide treatment before the feed of phosphate had been entirely stopped.

Some ten weeks after the stoppage of phosphate feed the boiler was shut down over a week-end for soaking the radiant superheater, but was not opened up for internal inspection. Upon restarting and after being in normal operation for several hours, a bottom-row screen tube ruptured at a short distance forward from a downward bend, located a short distance from the rear header. This tube was the fourth one from one side of the boiler. The fourth tube from the other side also was bulged at

the same relative location, but did not fail. No other tubes had any evidence of overheating.

Inspection of the screen drum showed an abundant accumulation of egg-shell scale chips, analysis of which showed them to be magnesium hydroxy phosphate, as observed during the previous inspection. These chips mixed with an equal amount of sludge had accumulated to a depth of about five inches, toward the ends of the screen drum, which is about level with the mouth of the tube that failed.

Apparently circulation through the affected tubes during the starting-up period was not rapid enough to sweep out the deposit of scale and sludge which had accumulated while shutting down the boiler, and resulted in eventual failure.

During the failure outage, the rear downcomer sections were turbined in order to get rid of most of the egg-shell scale. Subsequent inspection about six weeks later showed practically no chips in the screen drum and very little elsewhere. Complete turbining of the entire boiler was done at this time.

Inspections made after the continued use of barium chloride in conjunction with magnesium oxide, have shown only a very slight tendency for adherent deposits in the rear downcomer tubes. The feedwater trough has shown no sign of adherent deposits.

Calcium Scale Prevention in the Absence of Phosphate

In continuing the early trial of magnesium treatment, assurance was desired that material was or was not gathering on heat-absorbing surfaces, so thermocouples were peened into three front-wall tubes on the front side where metal temperatures would be a maximum. One of the tubes had been just previously turbined, so was known to be thoroughly clean. Subsequent operation had shown no difference between the turbined tube and others that were not, nor have day-to-day temperatures shown any definite trend. They have drifted up and down between 600 and 700 F with accumulation and removal of ash deposits on the furnace side of the tubes.

In the prevention of calcium scale, the desire for an anion that would precipitate calcium and not interfere with silica removal by magnesium, prompted a short trial of 50 ppm sodium fluoride in the boiler water. No effect on silica removal was apparent, but the fact that the addition of 16 ppm calcium in the form of lime caused no disappearance of the fluoride, indicated its ineffectiveness for scale prevention. The trial was shortly abandoned.

At the present time, assurance of little if any scale is afforded by the use of treatment chemicals practically free from calcium, excellent condenser tightness, and operation of the softeners to maintain $^1/_4$ ppm or less of $CaCO_3$ in the treated makeup. To obtain this low calcium in the treated makeup water, the softener capacity and flow rate have both been reduced to 83 per cent of the original rated values, and the amount of regeneration chemicals has been increased.

The $^1/_4$ ppm figure quoted above is an average of both softener units, one of which passes only 0.05 ppm and the other 0.5 ppm $CaCO_3$ under the same operating conditions. It is expected that corrective measures now planned will reduce calcium in the effluents to less than 0.1 ppm $CaCO_3$ average and will permit resumption of maximum flow rates.

Organic Matter in Boiler Water

When full-load heating conditions were encountered during the current heating season, unusually rapid clogging of the high-pressure end of the machine around No. 4 and No. 5 bleed points was encountered. Boiler alkalinity was low, sulphate was held to reasonable values with barium chloride and chloride content of the water not excessive. The resulting concentrations with 10 per cent blowdown (makeup basis) were

NaOH	7
Na_2SO_4	90
NaCl	140
SiO_2	1.8
Na_2SO_3	1.5
Suspended	100

Despite these apparently favorable conditions, stage pressures, especially No. 5, kept mounting at the very rapid rate of 3 per cent per day. The reason for this was not apparent until during a week-end outage there was occasion to inspect the interior of the vacuum deaerator used for degasifying the softener effluent. In the bottom of the deaerator was found a considerable amount of extremely fine softener zeolite that had not been evident on previous inspections. Plainly, this material was finding its way into the boiler. Tests of the boiler water with Folin's reagent for tannins indicated the presence of a considerable amount of organic matter, apparently due to breakdown of the softener zeolite under boiler temperatures.

Presence of the zeolite in the makeup seemed due to accumulations in a certain run of pipe during the softener rinsing process. A slight modification of procedure was instituted to flush this accumulation to the sewer. An immediate 80 per cent decrease in organic content of the boiler water resulted and stage pressure increases returned to normal slow rates (about $^1/_5$ per cent per day). Deposits were easily removed by water washing.

During this period of abnormal high-pressure-end clogging, insoluble silica deposits did not occur appreciably in the lower end of the machine.

Coincident with the change in softener procedure, the makeup load was limited to 83 per cent of its maximum to reduce the calcium content of the softener effluent. The effect of maximum makeup loads on organic matter with the modified procedure is therefore still to be finally determined.

Turbine Deposit Experience at Low Makeup Plants

At other 1300-psi plants of this company's system where makeup is very low and conventional phosphate treatment used, silica values in the boiler water have been comparable to these obtained at Commerce Street with magnesium oxide treatment. Insoluble silica deposits on turbine blading have been about the same as now being experienced at Commerce Street.

During early operation of Port Washington No. 1 and 2 units, boiler-water silica was around 2 ppm. Later reduction of this value to 0.7 ppm has resulted in appreciably less silica deposit on turbine blading. In attempting more nearly to perfect turbine cleanliness, No. 2 boiler silica has now been reduced to 0.3 ppm by careful reduction of silica contamination. Water-soluble deposits have been no particular problem due to low concentrations carried. The small amounts that do form are taken care of by condensation during outages.

The British Grid in 1945

The Central Electricity Board is directing its energies to overcoming, as quickly as possible, the difficulties inherent in the reconversion period to insure that the Grid contributes to rehabilitation in Great Britain as effectively as it contributed to the prosecution of the war. The Board's Annual Report covering the year 1945 states that although the return to normal conditions is expected, several years will be required to accomplish the necessary repairs, replacement and expansion.

The Report details the position regarding generating plant capacity in the stations associated with the Grid and states that for the four-year period ending with 1949 the total plant extension program comprises 4,619,200 kw capacity. This expansion includes 18 new stations, construction of which is necessary due to the limited room for extending existing generating stations.

The Board has been greatly concerned with the coal situation during the year when stocks of some stations were depleted to as low as one to two weeks' supply. This situation was aggravated by the inferior and often unsuitable quality of much of the coal supplied. Since 1939 there has been a marked increase in the ash content of the coal, resulting in unnecessary transport, reduced efficiency and increased maintenance costs. It is estimated that these factors combined impose an added financial burden on the consumers of electricity of some £2,000,000 a year.

The average price of coal for power generation has more than doubled since 1938, amounting in 1945 to approximately $8.75 per long ton. Although the return to peacetime conditions has resulted in certain operating economies, thus lowering the fuel consumption per kilowatt-hour, this is not sufficient to balance the increased cost of coal. The average fuel cost per kilowatt-hour increased in 1945 to 125 per cent of the 1938 level. This item has been the predominant factor in increasing the average generating cost.

The wartime peak of 38,356,000,000 kwhr generated in 1944 was 57.4 per cent higher than that for 1938. In 1945 this fell off 2.8 per cent as was to be expected with the end of the war. According to the Report, there is reason to expect that, when the immediate difficulties of postwar reconversion have been surmounted, the rate of increase will approach the rapid and continious rate experienced prior to the war.

During 1945, 99.1 per cent of the electricity supplied in Great Britain (excluding North Scotland) was produced by stations which were generating for the Board. At the end of 1945 there were 142 stations with an aggregate installed capacity of 11,315,931 kw associated with the Grid, while 51 others were operating for the Board under temporary arrangements.

The maximum demand on the Grid system occurred on January 25, 1945, when the total simultaneous demand rose to 8,653,000 kw. It was not necessary to shed load on this day but the frequency dropped to 49.1 cycles. In order to have maintained 50 cycles, the load would have been at least 8,792,000 kw. On that day 16 per cent of the output capacity of stations operating under direction of the Board was out of service. This compares very unfavorably with pre-war operation when labor for maintenance and repair was much more adequate. The load factor on the Grid system in 1945 was 45.0 per cent as compared to 47.6 per cent in 1944.

Pellets from Anthracite Fines

With a view to finding an economic means of utilizing fine-sized anthracite rejects below No. 4 buckwheat, an investigation by the Anthracite Institute and Pennsylvania State College has led to the extrusion of this fuel in the form of pellets which on test were burned successfully on a traveling-grate stoker which had previously burned No. 4 buckwheat. No changes were made in the furnace or the stoker grate, but a deeper fuel bed was carried to offset the somewhat more porous and more uniform sizing of the fuel. Previous to burning, the pellets were air dried and although shipped in burlap bags a considerable distance, they held their original shape without objectionable degradation. No attempt was made to develop maximum capacity but at a combustion rate of 25 lb per sq ft per hr the burning was reported as uniform with no signs of blowholes. The ash content was 27 per cent.

Corrosion-Erosion of Boiler Feed Pumps

The recently published 1944–45 Report of the E.E.I. Prime Movers Subcommittee Report on "Boiler Auxiliaries" contains a summary of the results of a survey among operating companies and pump manufacturers with reference to boiler feed pump corrosion-erosion. Of 52 high-pressure installations covered, 24 reported troubles of this character. Many of the remaining 28 trouble-free installations employed pumps of stainless steel construction. In fact, there was no case of corrosion-erosion failure where 5 per cent or higher chromium was used for pump parts, and many have eliminated the trouble by installing alloy-steel parts or by depositing alloy filler metal on the existing carbon-steel parts. In a few cases the difficulty was overcome by changing feedwater conditions, such as raising the pH, with recirculation or feeding sodium dichromate periodically.

While no definite conclusions were reached as to the primary cause of the trouble, it would appear from the investigation that stations operating with carbon-steel casings can probably alleviate the condition by refraining from the use of sodium sulphite, by maintaining a pH between 9 and 9.5, and by rotating their pumps in service. The difficulty does not appear to be associated with high temperature, as was at first suspected.

The study, as applying to existing carbon-steel pumping equipment, indicates (1) that black ferrous oxide, which is most frequently associated with the presence of sodium sulphite, is more easily eroded away from the metal surface than red ferric oxide; (2) that a high pH value is most favorable, providing it is due to a definite alkaline salt addition, rather than to the presence of transient ammonia; (3) that pumps rotated in service under water conditions which develop a red ferric oxide coating have a better record than those operating continuously, the reverse being true where a black oxide coating exists; and (4) that where the sulphite content of boiler water exceeds 5 to 10 ppm there is a tendency for it to break down.

There is nothing positive to indicate that a small amount of oxygen, and the red oxide coating which may result therefrom, is sufficiently protective to avoid corrosion-erosion where velocities are not excessive. Nevertheless, the committee, viewing this question broadly, was of the opinion that it might be helpful.

The percentage of failures with heads over 300 psi per stage was the same as that in which the stage pressure was less than 200 psi, thus indicating that stage pressure, by itself, is not a factor in evaluating potential corrosion-erosion troubles. It was noted, however, that variable-speed pumps show a lower percentage of such difficulties than those operated at constant speed.

German Power Practice

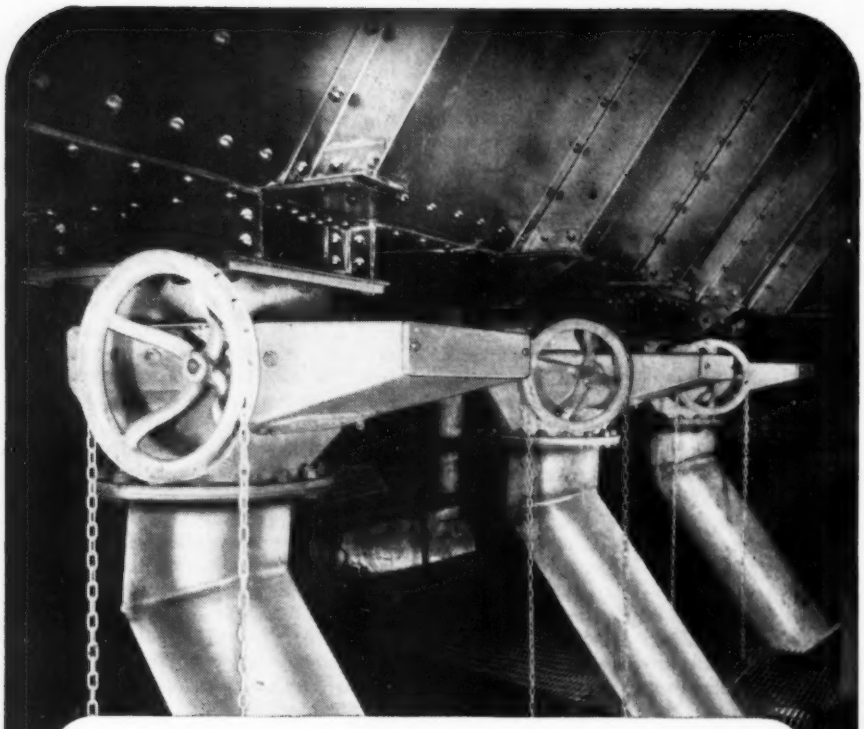
Wartime advances by the German power industry, though limited, include several innovations in technical operation and construction of potential interest to American industry, according to a report released by the Office of the Publication Board, Department of Commerce. The report, covering a detailed survey of the German power industry, equipment and operating methods, was prepared by investigators of the Technical Industrial Intelligence Branch, Department of Commerce.

The investigators learned that BEWAG, Berlin's principal electric system, operated without a major breakdown from 1927 to 1944, and maintained an adequate power supply even during the last year of the war. This system consists of nine central stations in Berlin itself, all interconnected, and tied in with a number of power plants of companies outside Berlin.

Among the wartime innovations mentioned in the report is the use at the Bohlen plant of channel-type superheaters, added ahead of the main superheater section in some of the boilers to overcome slagging difficulties.

A Schmidt-Hartmann type boiler served as a double evaporation unit at the Bitterfeld plant. The saturated steam generated in the boiler tubes was collected in an upper drum. From there it passed through a heat exchanger drum, where the second cycle steam was generated and passed to the superheaters and turbines. Steam from the primary boiler generation was condensed in the heat exchanger drum, and the condensate was returned to the primary boiler system. The primary boiler system required only one or two gallons of makeup water per week.

In general, the Germans showed a tendency to obtain turbine-generated power and supply process steam through the use of steam transformers. In this way they



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obtained steam transformer condensate or drips for the high-pressure feed-water system.

It is also noted that the German definition of good steam purity is 3 to 4 ppm solids in the steam, in contrast with American standards of much higher purity.

HENRY KREISINGER

Henry Kreisinger, Director of Research for Combustion Engineering Company and an internationally recognized authority on fuels, died following a brief illness at the Presbyterian Hospital, New York, on Tuesday afternoon, May 7.

Born at Radnice, Bohemia, in 1876, Mr. Kreisinger came to the United States in 1891 and secured employment in various machine shops in or about Chicago earning the means to prepare himself for a technical education. He entered the University of Illinois in 1900 and graduated in 1904 with the degree of B.S. in Mechanical Engineering. In 1906 he received the M.E. degree.

His early work in fuels was in connection with tests conducted by the U. S. Geological Survey at St. Louis, Norfolk and Pittsburgh from 1907 to 1910. For the next three years he was fuel engineer of the Clinchfield Fuel Company and then joined the U. S. Bureau of Mines, where he became supervising engineer in charge of the fuel section. He joined Combustion Engineering Company in 1920 and devoted much of his time in the next few years to pioneer work in the development of pulverized-coal firing for steam boilers and the application of water-cooling to furnace bottoms, followed by completely water-cooled furnaces, which made possible the widespread use of pulverized-coal-firing for large steam generating units. In recent years, as Director of Research of Combustion Engineering Company, he has been responsible for extensive investigations of furnace temperature and heat absorption. He was the holder of many patents dealing with fuel-burning applications.

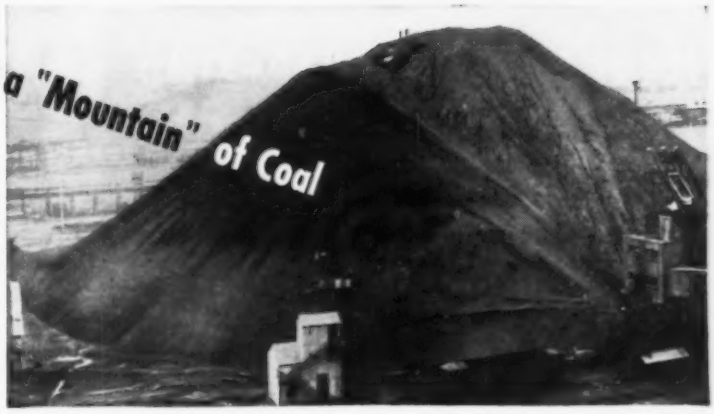
Mr. Kreisinger was long a member of the American Society of Mechanical Engineers, the American Institute of Mining and Metallurgical Engineers, and the American Association for the Advancement of Science, and was the recipient of many engineering honors, including the Chanute Medal and the Percy Nicholls Award in 1943 for notable scientific and industrial achievement in the field of solid fuels. He was also the author of numerous papers before engineering societies and articles on fuels and heat-transfer subjects in the technical press.

Surviving are his wife, Ella M. Kreisinger; a son, Robert Kreisinger; and two daughters, Dr. Elizabeth C. Kreisinger and Mrs. Arthur Selvey.

E.E.I. to Meet in June

The first post-war annual convention of the Edison Electric Institute will be held at the Waldorf-Astoria Hotel in New York on June 3–5. A whole session will be given over to the subject of atomic energy in which the views of several leaders in nuclear research and in the utility field will be expressed. Other sessions will discuss such subjects as opportunities for young men in the utility field, distribution, electrical problems, commercial programs, domestic load applications, rural electrification, industrial relations, and general problems related to the electrical utility field.

Handling a "Mountain" of Coal



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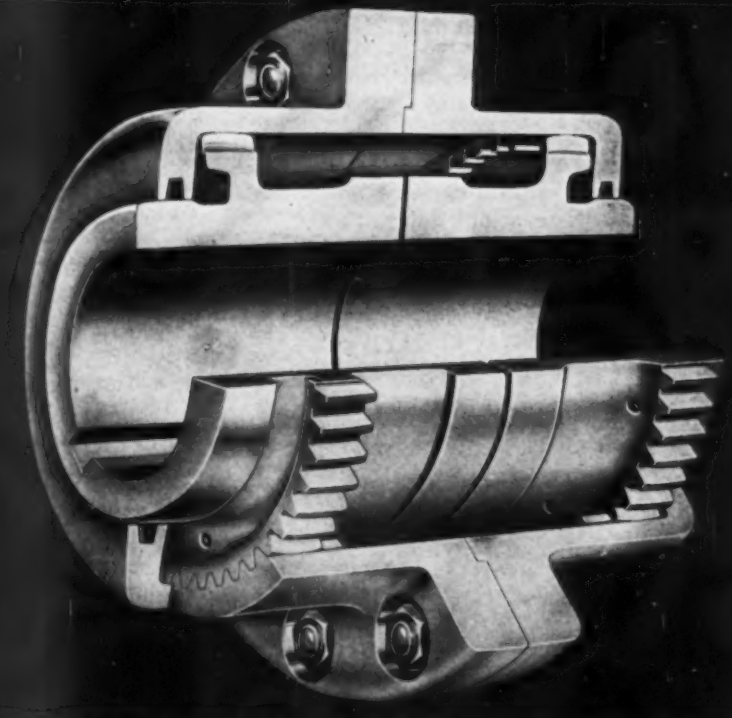

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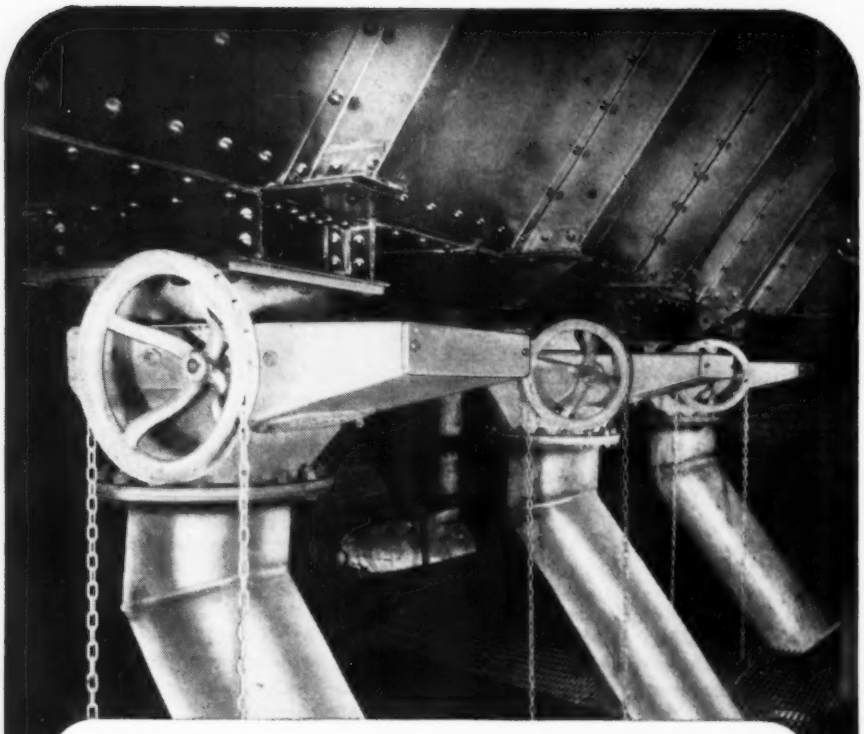
FLEXIBLE COUPLINGS

POOLE FOUNDRY & MACHINE COMPANY WOODBERRY, BALTIMORE, MD.



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★ CONICAL Non-Segregating Coal Distributors ★ S.E.CO. Coal Valves and Coal Scales

obtained steam transformer condensate or drips for the high-pressure feed-water system.

It is also noted that the German definition of good steam purity is 3 to 4 ppm solids in the steam, in contrast with American standards of much higher purity.

HENRY KREISINGER

Henry Kreisinger, Director of Research for Combustion Engineering Company and an internationally recognized authority on fuels, died following a brief illness at the Presbyterian Hospital, New York, on Tuesday afternoon, May 7.

Born at Radnice, Bohemia, in 1876, Mr. Kreisinger came to the United States in 1891 and secured employment in various machine shops in or about Chicago earning the means to prepare himself for a technical education. He entered the University of Illinois in 1900 and graduated in 1904 with the degree of B.S. in Mechanical Engineering. In 1906 he received the M.E. degree.

His early work in fuels was in connection with tests conducted by the U. S. Geological Survey at St. Louis, Norfolk and Pittsburgh from 1907 to 1910. For the next three years he was fuel engineer of the Clinchfield Fuel Company and then joined the U. S. Bureau of Mines, where he became supervising engineer in charge of the fuel section. He joined Combustion Engineering Company in 1920 and devoted much of his time in the next few years to pioneer work in the development of pulverized-coal firing for steam boilers and the application of water-cooling to furnace bottoms, followed by completely water-cooled furnaces, which made possible the widespread use of pulverized-coal-firing for large steam generating units. In recent years, as Director of Research of Combustion Engineering Company, he has been responsible for extensive investigations of furnace temperature and heat absorption. He was the holder of many patents dealing with fuel-burning applications.

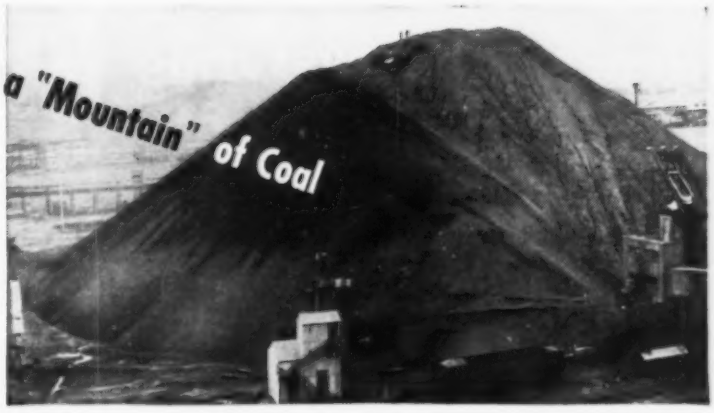
Mr. Kreisinger was long a member of the American Society of Mechanical Engineers, the American Institute of Mining and Metallurgical Engineers, and the American Association for the Advancement of Science, and was the recipient of many engineering honors, including the Chanute Medal and the Percy Nicholls Award in 1943 for notable scientific and industrial achievement in the field of solid fuels. He was also the author of numerous papers before engineering societies and articles on fuels and heat-transfer subjects in the technical press.

Surviving are his wife, Ella M. Kreisinger; a son, Robert Kreisinger; and two daughters, Dr. Elizabeth C. Kreisinger and Mrs. Arthur Selvey.

E.E.I. to Meet in June

The first post-war annual convention of the Edison Electric Institute will be held at the Waldorf-Astoria Hotel in New York on June 3–5. A whole session will be given over to the subject of atomic energy in which the views of several leaders in nuclear research and in the utility field will be expressed. Other sessions will discuss such subjects as opportunities for young men in the utility field, distribution, electrical problems, commercial programs, domestic load applications, rural electrification, industrial relations, and general problems related to the electrical utility field.

Handling a "Mountain" of Coal



● One industrial plant increased its coal-pile depth from 48 to 116 feet, and boosted pile capacity from 39,000 to 150,000 tons in limited space. Although probably the highest coal pile in the world, fire hazard is actually reduced because pressure within the pile minimizes the air content.

To accomplish this, Beaumont engineers installed an aerial bridle system suspended from three 85' towers with the tail block position remotely controlled from the operator's station on the previously installed Beaumont cable drag scraper system.

Although your coal storage problem may not be as difficult as this one, chances are that Beaumont's 40 years' experience can save you time, trouble and money in finding the solution. Write outlining your requirements.

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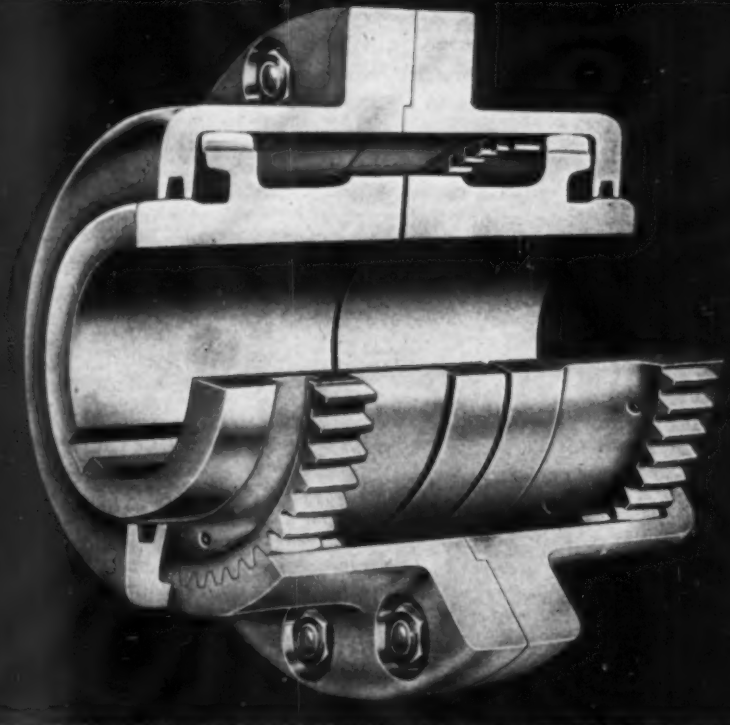

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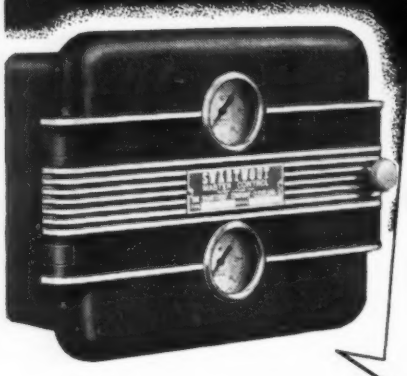

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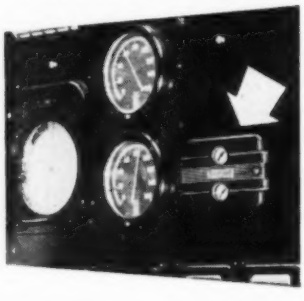
Swartwout Master Pressure Control

The safety you need for personnel, equipment and work in process requires dependable accuracy in controlling modern high pressures. Almost unbelievably sensitive in its reaction to pressure changes, the new Swartwout "P-2" Pressure Master Control acts instantly to hold forces to a narrow range through its control of regulating valves. It's a precision instrument of simple rugged construction. Requires but two adjustments. Handles problems of regulation of steam or other vapors and fluids. Assures stability of control for reducing, relief, spill-over, pump control and other functions.

Swartwout Type P-2 Pressure Master is compact, soundly engineered—is housed in a modern dust-proof case, easily accessible through front hinged door: a practical solution to many of *your* regulation problems.



Put your pressure regulation on a worry-free basis. Write today for Swartwout Data Unit No. S-203 describing the new P-2 Pressure Master Control.

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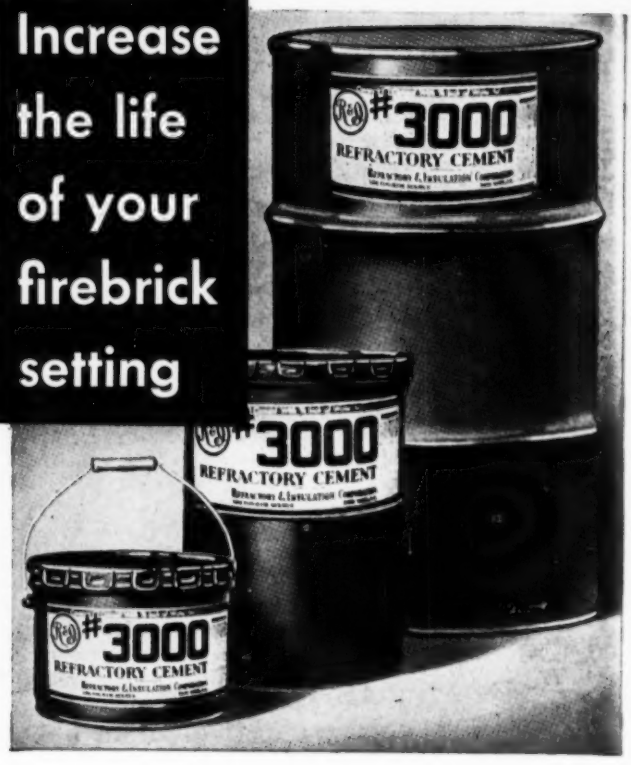
THE SWARTWOUT COMPANY • 18511 Euclid Ave., Cleveland 12, Ohio

Increase the life of your firebrick setting



R & I #3000 Refractory Cement clings to firebrick with a bulldog grip because it is so finely ground that it penetrates far into every pore of the brick. This feature permits its use for thin joints.

It does not shrink, spall, bulge, crack, puff or fall out under the most severe firing conditions. Brick are protected against slag and abrasion.

Intermittent firing will not crack #3000 for it has the same expansion and contraction as #1 firebrick.

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Look for the green drum. Your supply house has it.

Bulletin R-44 contains some interesting facts. Write for a copy.

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REVIEW OF NEW BOOKS

Any of the books here reviewed may be secured through Combustion Publishing Company, Inc., 200 Madison Ave., N. Y.

Elementary Mechanics of Fluids

By **Hunter Rouse**

The author, who is professor of fluid mechanics and director of hydraulic research at the State University of Iowa, has adopted a method of presentation differing from the conventional that is unique yet makes readily understandable the principles underlying the manifold uses in today's engineering of fluid flow. This is accomplished by development of the usual equations for flow of fluids starting from the basic equations of mechanics. Derivations are readily followed. Problems are included, both as examples of application of the text and of a nature akin to those the practicing engineer encounters.

The book contains eleven chapters, namely, Introduction to the Study of Fluid Motion, Fluid Velocity and Acceleration, Pressure Variation in Accelerated Flow, Effects of Gravity on Fluid Motion, One Dimensional Method of Flow Analysis, Effects of Viscosity on Fluid Motion, Surface Resistance, Form Resistance, Lift and Propulsion, Surface Tension, The Role of Compressibility in Fluid Motion. There is also an appendix in which is summarized useful information on the application of the principles of dimensional analysis and on the mechanical properties of commonly used liquids and gases.

For those desiring to delve deeper into specific problems the book will be found well documented with pertinent references.

The volume contains 376 pages, 6 × 9¼, and is priced at $4.00.

Statistical Thermodynamics

By **Erwin Schrödinger**

This is a course of seminar lectures delivered at the School of Theoretical Physics, Dublin Institute for Advanced Studies, the object of which, according to Professor Schrödinger, was "to develop briefly one simple, unified, standard method capable of dealing, without changing the fundamental attitude, with all cases and with every new problem that may arise." The text, which is far from elementary and comprises considerable mathematical analysis, is intended for the more advanced student of thermodynamics.

The author has condensed those topics which appear in many textbooks but has dealt at greater length with vital points which are usually passed over in all but large monographs (such as Fowler's and Tolman's). He discusses two different attitudes as regards the physical application of the mathematical result.

There are 88 pages, approximately 5 × 7 in., and the price is $1.50.

Inspection Handbook for Manual Metal-Arc Welding

This handbook of 156 pages, prepared by the American Welding Society, is the most complete and authoritative manual that has yet been published on welding inspection. It covers the requirements and duties of a welding inspector, methods of testing welds, and contains a comprehensive description of weld inspection by visual, magnetic-particle and radiographic methods. One section discusses the principal types of weld defects and indicates how they may be detected and corrected. The book is written in simple language and is intended to serve as a reliable source of information on any welding inspection problem. The price is $1.50.

Fluid Measurement

A complete yet concise treatment of fluid measurement, including related factors, equipment, equations and computations in terms of steam, water, oil and gas flow, is offered in a new edition of "The Flow Meter Engineering Handbook," compiled and edited by Louis Gess and R. D. Irwin of the flowmeter engineering department of Brown Instrument Company division of Minneapolis-Honeywell Regulator Company.

The first chapter discusses principles of orifice meter measurement followed by succeeding chapters on the orifice plate and differential connections, flowmeter details, flow approximation tables, derivations of working formula, working equations, compressibility of gases, relationship between coefficient of discharge, viscosity of fluids and orifice calculations for steam, water, oil and gas flow. The final chapters are given over to a summary of equations and nomenclature, changes for corrections in operating conditions, and volume computations.

It is priced at $2.50.

Supplement to Book of A.S.T.M. Standards

To keep up to date the biennially published Book of A.S.T.M. Standards, the American Society for Testing Materials in the intervening year issues supplements to each part of the book. The 1945 Supplements recently issued in three parts, give in their latest approved form some 230 specifications, tests and definitions which were either issued for the first time in 1945 or revised since their appearance in the 1944 Book.

Part I on Metals, of 395 pages, includes over 85 standards covering ferrous and nonferrous materials. *Part II on Nonmetallic Materials (Constructional)*, of 250 pages, has 50 standards. *Part III on Nonmetallic Materials (General)*, the largest volume, with 500 pages includes over 95 standards. Specifications and tests cover coal, thermometers, petroleum products and lubricants, electrical insulating materials, plastics, rubber products, shipping containers, textile materials, paper and paper products, soaps and other detergents, naval stores, water for industrial uses and industrial aromatic hydrocarbons.

Copies are $4.00 per part, or all three parts for $12.00. Each is bound in a durable cloth binding. Heavy-leather bindings are available upon the additional payment of $2.00 per part. The three 1945 Supplements, plus the Book of Standards, give a complete set of all A.S.T.M. specifications and tests, excepting those on chemical analysis of metals which are in a special volume.

Smoke Abatement

Proceedings of the 1945 Conference on Smoke Abatement and Conservation of Fuels has recently been published by the Smoke Prevention Association of America. Issued in multigraphed form covering 105 pages with illustrations, the text contains fifteen papers presented at the Columbus, O., meeting last October, together with the discussion on each. The titles include District Heating, Trends in Development of Smokeless Fuels, National Fuel Conservation, Railroad Smoke Prevention, Elimination of Black Smoke, Meteorology and Smoke Abatement, Dust Collection Devices for Preventing Atmospheric Pollution, The Locomotive Gas Turbine, Under - Grate Air Distribution, Ring Blower Design, Combustion Controls, The Application and Interpretation of Coal Analysis, and Elimination of Nuisances Accompanying Incineration.

Copies may be obtained from the Publicity Director of the Smoke Prevention Association of America at City Hall Square Building, Chicago 2, Ill. Price, $2.

Materials Handling Manual

Edited by M. M. Williamson and G. W. Williamson

This volume which deals with British practice, covers the handling of materials of all kinds as encountered in various industries. Included are chapters on coal and ash handling for modern power stations and others on traveling, jib and mobile cranes, as well as speed transmission equipment. Typical layouts are provided. Each chapter is under separate authorship.

The text is profusely illustrated by more than four hundred pictures and diagrams. There are 488 pages, 8½ × 5½ in. and the price is 30 shillings (approximately $6.00).

Graphical Symbols

The A.S.A. has just issued the "American Standard Graphical Symbols for Electric Power and Control." Sponsored by A.S.M.E. and A.I.E.E., these symbols were prepared by representatives of various bodies that have occasion to employ such symbols on drawings. Copies are available at 40 cents each from the American Standards Association, 70 E. 45th St., New York 17, N. Y.

NEW CATALOGS AND BULLETINS

Any of these publications will be sent on request

Alkalinity Titrations

An improved "Methyl-Purple" indicator, replacing methyl-orange for total alkalinity titrations, is described in a bulletin issued by the Fleisher Chemical Company.

Boiler Water Treatment

A packaged unit for boiler water treatment has just been announced by "Proportioneers, Inc." This new unit includes an "Adjust-O-Feeder" compactly mounted with a motor on the same base with a chemical tank and agitator. It automatically feeds treating chemicals and compounds for the control of scale, pitting and corrosion.

Condenser Tube Inserts

A new bulletin just issued by Condenser Service & Engineering Co., describes "Flowrites", metal inserts for inlet ends of condenser tubes, which prevent tube end erosion. It includes a report of tests conducted at the Massachusetts Institute of Technology, with tables, graphs, and data showing how condenser operation is improved with Flowrites. Installation instructions are included.

Evaporators

A new bulletin on evaporators for distilling boiler feed makeup has been issued by The Griscom-Russell Co. Besides describing and illustrating different types of "Bentube" evaporators for various capacities and pressures, the bulletin discusses evaporator systems and their association with plant heat balance.

Feedwater Regulators

Bailey Meter Company has published an attractive 8-page bulletin (No. 83-C) describing the features of its Thermo-Hydraulic Feedwater Regulators. A colorful full-page schematic diagram illustrates the text describing the principles of operation.

Fuel Loss Calculator

A slide rule type of calculator of particular interest to boiler room operators is being offered by The Hays Corporation, Michigan City. This is used after the per cent of CO_2 in the flue gas, the temperature of the flue gas and the room temperature have been determined, and is based on several fuels of different analyses and a wide range of flue gas temperatures.

The figures on the calculator reveal the per cent of total heat loss in the flue gas. Instructions accompanying the calculator show how heat loss can be converted into fuel loss which is really the information the engineer is seeking.

The calculator is being distributed to all interested users without cost.

Flow Indicators

A full detailed description of Schutte & Koerting flow indicators, including sectional drawings of construction features, operation principles, applications and characteristics of the different types are available in Bulletin No. 18-W, Schutte and Koerting Co., 12th & Thompson Sts., Philadelphia 22, Pa.

Gas Analyzer

The Hays Corporation announces the development of a special analyzer for testing the high purity of oxygen, carbon dioxide, and nitrogen in the range from 90 to 100 per cent. It is known as the Hays Series "E" and is quite similar to the standard orsat but its technique in operation differs somewhat.

It is offered in two styles—a wall mounted model for permanent installation and a portable model supplied in a neat metal case with leather carrying handle. It may be had with a single unit or with two units. A junior model (Series EJ) is also obtainable with a burette capacity of 30 cc. The smaller model measures $6^1/_4$" $\times$ $9^5/_8$" $\times$ $3^3/_4$" and weighs, fully charged, less than six pounds.

All models feature a new four-way valve designed by Hays engineers to conserve space and facilitate operation. An explanatory bulletin (Pub. 45-743) will be sent to those interested.

Power Plant Equipment

Bulletin Q-12 issued by the Elliott Company describes and illustrates equipment produced by that company for power plants and industrial processes, ranging from steam turbines, motors, generators and feedwater heaters to turbochargers, steam jet ejectors and centrifugal blowers.

Thermocouples

Wheelco Instruments Company has issued a new 32-page edition of its Thermocouple Data Book and Catalog. (Bulletin S2-6). It gives information on selection of proper thermocouples and carries installation aids. It describes and lists prices and recommendations on thermocouples, thermocouple wire, lead wire, heads, connectors, plug and socket assemblies, insulators, and protecting tubes.

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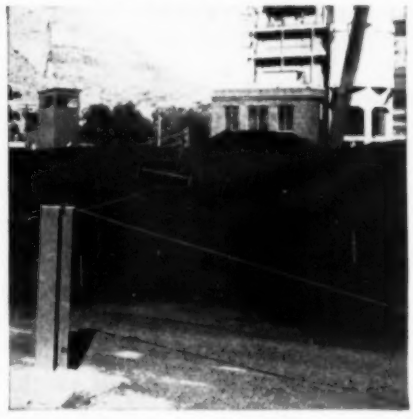

Picture shows stockpile at 25,000 KW. central station where a 1 cu. yd. Sauerman Scraper stores and reclaims from 130,000 tons of coal per year. These scrapers are made in sizes to carry from ¼-ton to 8-ton loads of coal.

Plant executives can tell you that they have licked the coal handling problem—that they are storing and reclaiming their coal at a cost of only a few cents a ton—that with Sauerman equipment they are able to utilize ground space of any size and shape, building higher piles than otherwise possible—piling in compact layers with no segregation—no air pockets for spontaneous combustion.

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BOOKS

1—Marine Engineers' Handbook

EDITED BY PROF. J. M. LABBERTON

2013 pages $4^1/_2 \times 7$ $7.50

This handbook is designed by the publishers as a successor to Sterling's Marine Engineers' Handbook, once the "Bible" of the marine engineering profession. The work has been practically re-written and is as modern and up-to-date as the ships now under construction.

The handbook is a compilation of the work of sixty-three specialists under the editorship of Professor J. M. Labberton.

While principally a designer's and technical student's handbook, the operating engineer will find a considerable amount of helpful information, particularly in the section on boilers.

The field is thoroughly covered with sections on engineering fundamentals, hull design and construction, marine power generation, boilers of various types, oil firing and handling turbines, steam engines, internal combustion engines, propulsion, auxiliaries, deck machinery, heating and ventilating, electrical engineering, refrigeration, tests and ship trials. The subjects are well covered from the basic theory and equations, and amplified with design data, charts, curves, descriptions and construction details.

2—Boiler Room Questions and Answers

BY ALEX HIGGINS

139 pages $8^1/_2 \times 11$ Price $3.00

The need for a reliable and up-to-date book on boiler room practice (and of particular merit for those men who are studying for licenses or certificates as operating engineers) has been adequately met in this volume by Alex Higgins. Parts of the book have already appeared in the pages of *Power* magazine, and many illustrations of fine quality support the text.

The Question and Answer form is excellent and the 26 chapters comprise a comprehensive review of typical examination questions on the essential principles of design, construction and operation of boilers and boiler room accessories. The Answers are couched in simple terms and offer the candidate for a license an excellent example of how to handle the questions posed to him in his written examination.

3—The Modern Gas Turbine

BY R. TOM SAWYER

216 pages 6×9 Price $4.00

Although the fundamental principle of the gas turbine was known more than 2000 years ago, its development in recent years has been so rapid that no one in the power generation field can afford to ignore its imminent possibilities. For this reason, Mr. Sawyer's book will have particular appeal to those engineers who want to be informed as to the latest applications of the gas turbine as a supercharger and as a prime mover.

The author has compiled an authoritative treatise which outlines the earliest concepts of the gas turbine and traces its development from hot air engines built at the beginning of the eighteenth century to modern times. It covers application to supercharged diesel engines and includes chapters on The Gas Turbine in Industry; in Marine Service; and also The Gas Turbine Locomotive. Concluding chapters deal with The Exhaust Turbo-supercharger on Aircraft Engines and The Gas Turbine as an Aircraft Prime Mover, including Jet Propulsion.

The book is generously illustrated and includes three pages of general references and a 10-page index.

4—Chemistry of Coal Utilization (2 volumes)

1850 pages Price $20.00

This book is in two volumes containing about 1850 pages and was sponsored by a special committee of the Division of Chemistry and Chemical Technology of the National Research Council. This committee, headed by Dr. H. H. Lowry of Carnegie Institute of Technology, consisted of forty members representing various research institutes and commercial organizations interested in coal. It arranged the subject matter into forty chapters, each dealing with one phase of the subject, and preparation of the text was assigned to twenty-nine authors, selected because of their training and experience. These authors reviewed some 15,000 pages of literature on the subject, published in ten languages. Wherever possible, digests of the original articles are incorporated and the text is well supplied with references to the original publications.

5—Applied Energy Conversion

BY B. G. A. SKROTSKI AND W. A. VOPAT

509 pages 6×9 Price $5.00

Despite its broad title, the text of this book deals with power plants of the steam, internal combustion, and hydro types, with considerable attention being paid to the general economic side of power production and performance. Typical equipment entering into such plants is briefly described and illustrated without going into design problems, as it is felt that these come within the province of specialists among the equipment manufacturers.

Beginning with a chapter on "Raw Energy," devoted to the classification and characteristics of coals, oil, gas and refuse fuels, the book takes up, in order, combustion calculations, methods of firing, steam-generating units, prime movers, feedwater systems, steam plant cycles and heat balance, diesel and gas engine plants, hydro power, power plant developments, general economic problems, load curves, selection of plant and equipment, and station performance and operating characteristics; also concluding chapters on specific energy problems and energy rates.

The text is written primarily for students in heat-power engineering, but it should also provide useful refresher reading for engineers already following the power plant line.

6—The Efficient Use of Fuel

PREPARED BY THE MINISTRY OF FUEL AND POWER

807 pages $8.50

This authoritative British handbook was assembled by 140 engineers, scientists and industrial associations, and is replete with information about fuels and their uses in a wide diversity of industries.

British coals and manufactured gas form the bulk of the fuels considered, and a brief chapter is devoted to oil and its utilization. To assist the reader, a complete bibliography of Fuel Research Papers is identified.

The book has an index and each of its thirty-four chapters has a short compendium in the Table of Contents.

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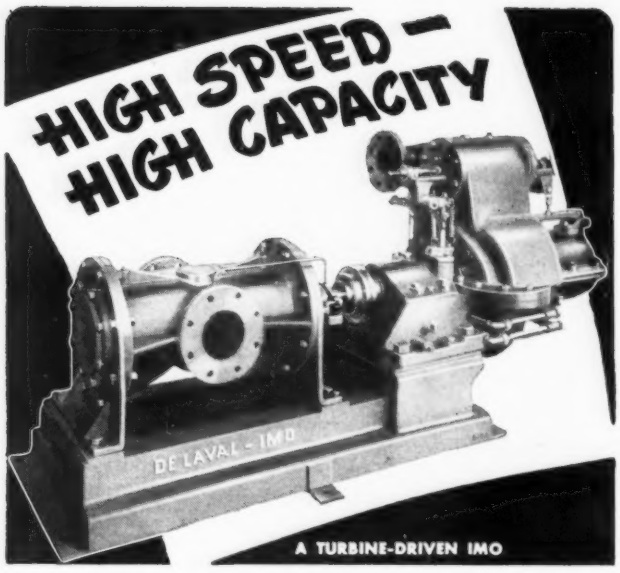

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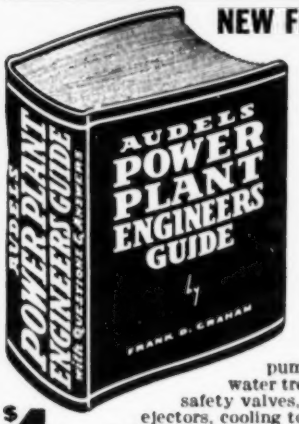

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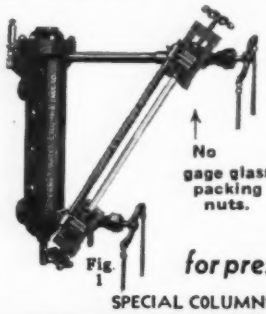

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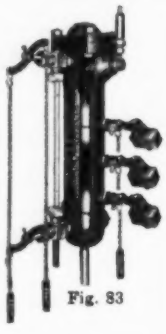

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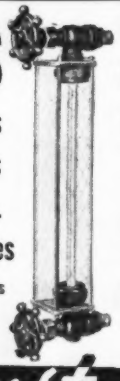

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Air Preheater Corporation, The 16
Aldrich Pump Company, The ..... Fourth Cover
Armstrong Cork Company 7
Armstrong Machine Works ..... 12 and 13
Theo. Audel & Company, Publishers 52

Bailey Meter Company 10
Bayer Company, The 17
Beaumont Birch Company 47
Buffalo Forge Company 6

Combustion Engineering Company, Inc. ..... Second Cover, 8 and 9
Combustion Publishing Company, Inc.—Book Department 51

De Laval Steam Turbine Company 52
Diamond Power Specialty Corporation ..... Third Cover

Ernst Water Column & Gage Company 52
Flexitallic Gasket Company 4
Foster Engineering Company 3

Globe Steel Tubes Company 11
Goetze Gasket & Packing Company, Inc. 19

Paul B. Huyette Company, Inc., The 30

National Aluminate Corporation 22
Northern Equipment Company 2

Pittsburgh Piping & Equipment Company 21
Poole Foundry & Machine Company 47
Wm. Powell Company, The 15
Prat-Daniel Corporation 1

Refractory & Insulation Corporation 48
Research Corporation 34

Sauerman Bros., Inc. 50
Stock Engineering Company 46
Swartwout Company, The 48

Thermix Engineering Company 20

Vulcan Soot Blower Corporation 14

Western Precipitation Corporation 18

Yarnall-Waring Company 5